AGRICULTURAL ECONOMICS RESEARCH

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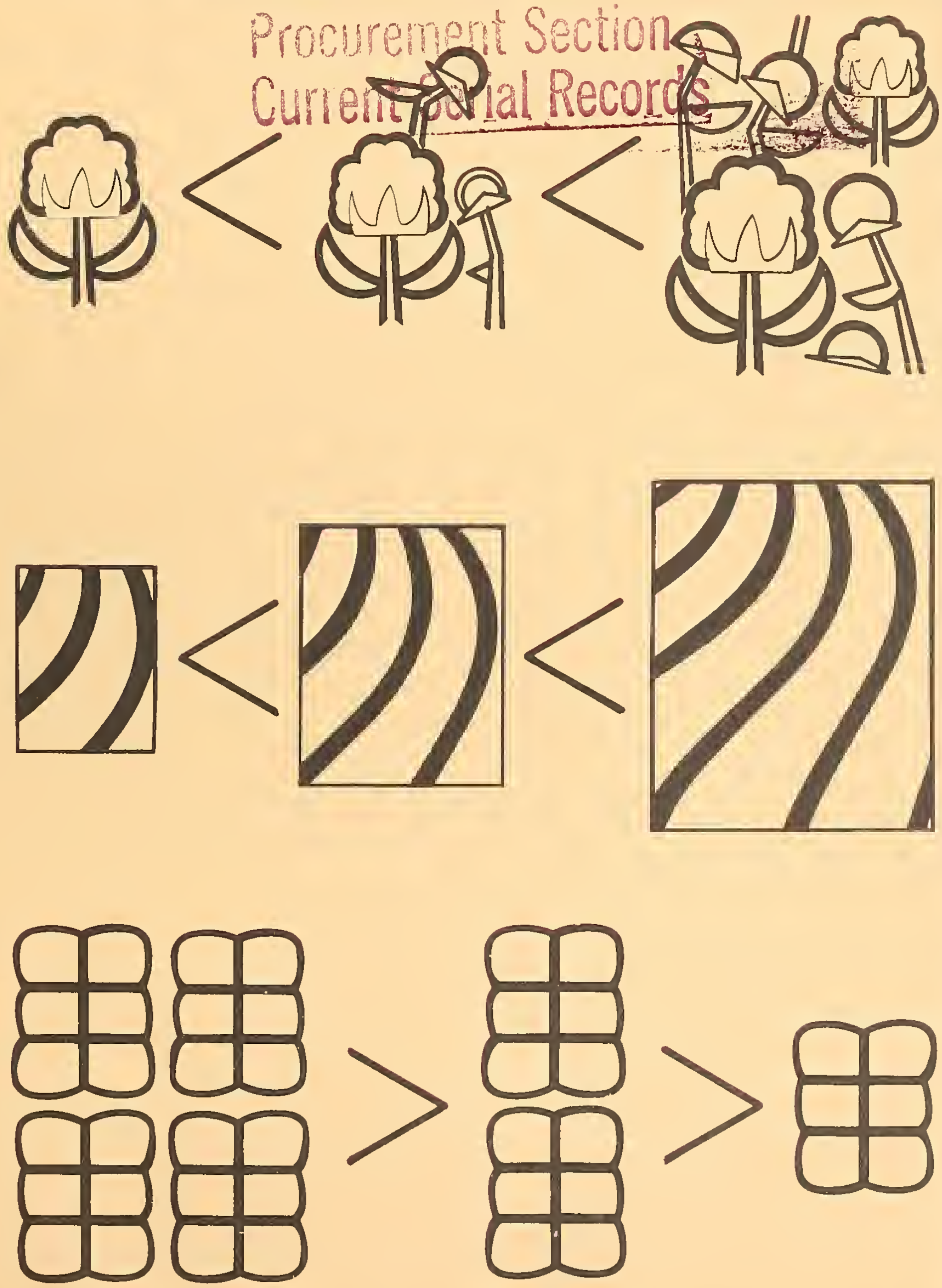
A greater harvest

from more land

could mean less yield per acre.



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Agricultural Economics Research

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"Pure economics has a remarkable way of pulling rabbits out of a hat," according to John R. Hicks, in his *Value and Capital*. Later, in *Capital and Growth*, Hicks carefully distinguished between pure and applied economics. Pure economics examines theoretical questions which can never be answered by an appeal to facts: applied economics incorporates strategic factors in models, while neglecting unimportant factors, and tests hypotheses by an appeal to facts.

Agricultural economists have always considered their discipline to be an applied one. They are deeply concerned with data problems and statistical inference. They tend to follow Hicks' maxim in *Value and Capital*: "The place of economic theory is to be the servant of applied economics."

The first article in this issue addresses an applied problem. It explains how USDA economists filled a data gap suddenly created in 1972, when the Farm Credit Administration stopped collecting interest rate and loan data from farm mortgages recorded on county records.

Strategic factors in forecasting cotton production response are tested by an appeal to facts in the second article. Cotton acreage and yield each tend to increase in response to higher prices received by farmers, other things being equal. But the increase in acreage may include poorer land, which has a tendency to reduce yield. These strategic, opposing interactions between acreage and yield need to be recognized in models which forecast production response.

A mathematical model used to project world trade in grain, oilseeds, and livestock is the subject of the third article. The author focuses on how demand by the livestock sector for feed grain is modeled. An appeal to facts shows that the interaction between the livestock and grain sectors affects longrun trends in an interesting way. The author finds, for example, that the livestock sector expands considerably when grain is plentiful, but contracts when it is scarce. The result is a relatively steady trend in world grain trade, with the livestock sector functioning as an informal grain reserve.

The fourth article makes no appeal to facts. The rabbit pulled from this hat is that gambling and insuring do not necessarily reflect different values and psychological preference patterns; each may reflect a rational adaptation to different environments. Hicks was concerned that we discover how the rabbits got in. In this theoretical article, they do so by assumptions concerning the rate of returns associated with a random variable. When a random variable enters an entrepreneur's production function with diminishing returns, profit maximization behavior is conservative and can be likened to insuring. And when a random variable enters with increasing returns, behavior is liberal and can be likened to gambling.

CLARK EDWARDS

On January 1, 1978, three USDA agencies—the Economic Research Service, the Statistical Reporting Service, and the Farmer Cooperative Service—merged into a new organization, the Economics, Statistics, and Cooperatives Service.

CONTENTS

The Secretary of Agriculture has determined that the publication of this periodical
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INTERREST RATES CHARGED AND AMOUNTS LOANED BY MAJOR FARM REAL ESTATE LENDERS

By Lindon J. Robison and David J. Leatham*

▲ Data on lending activities of major farm real estate lenders are summarized. The loan data show the amount of loans made and repaid during each year as well as the amount outstanding at the beginning of each year. The interest rate data show the contractual rates charged on new loans during each year plus estimates of the average rates on all outstanding loans at the beginning of each year. When data from primary sources are not available, the procedure used to obtain estimates is described. The USDA method for estimating interest charges is detailed along with some recent estimates.

▲ Keywords: Loans made, loans outstanding, interest rates, and interest charges.

INTRODUCTION

Farm real estate interest rates and loan data have many uses:

- To calculate interest charges on farm real estate loans.
- To estimate supply and demand for farm real estate loans (*5*).[1]
- To trace the relationship of the agricultural finance and national money markets (*6*).
- To explain the relative market shares of the farm real estate lenders (*7*).
- To predict future levels of interest rates and outstanding loan balances, information which can be used by farm borrowers and lenders in their financial investment decisions (*12*).

In the past, USDA's Economics, Statistics, and Cooperatives Service (ESCS), formerly the Economic Research Service, relied on the Farm Credit Administration for much of the interest rate and loan data, which it collected from farm mortgages recorded at county recorders' offices. However, in 1972 this practice was discontinued. To compensate, ESCS began to rely more heavily on data obtained directly from the farm real estate lenders, particularly Federal land banks, life insurance companies, and the Farmers Home Administration.

However, the other lenders, commercial banks, and individuals did not maintain many of the data series previously estimated.

In this article, we have two objectives: first, to identify which financial data are based on primary data and second, to estimate data no longer available from primary sources. Of course, these two objectives are complementary—observed relationships between primary data series should provide the basis for an estimation procedure. We measure these relationships statistically and use the results to provide estimates for the data series no longer available. These estimates are based on the discovered historical patterns and primary data which continue to be available.

We now proceed to identify the primary data, discuss the methodology used to estimate missing data series, and report the results in tables.

ORIGIN OF THE DATA

For any one lender, all loan information is summarized from three series: loans outstanding at the beginning of each year, loans made during the year, and loans repaid during the year. The loans outstanding data are stock variables listed as liabilities in the balance sheet of those who borrowed to purchase real estate. Loans made and loans repaid are flow variables and summarize debt flows during some time period. Loans made do not, however, necessarily represent net additions to real estate loans outstanding nor do loans repaid represent net reductions in loans outstanding. Many new loans are made to retire old ones. In fact, some lenders require borrowers to refinance their old loans if they want to

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[1] Italicized numbers in parentheses refer to items in the Bibliography at the end of this article.

increase the amount borrowed. Thus, the loans made data represent loans made to retire old loans as well as to buy more real estate. The loan repayment series reflects contractual payments on loan balances plus loans retired through refinancing.

Corresponding to loans outstanding are average interest rates on outstanding loans, referred to hereafter as the average rate. And corresponding to loans made are average interest rates charged on new loans, referred to hereafter as the new rate. The average rate reflects the average cost of real estate loans outstanding as of January 1. The new rate is the average cost of new loans acquired during a calendar year. The two, of course, are related: as changes occur in the new rate, the average rate on outstanding balances changes.

Which of the series are based on primary data? In tables 1 through 8, columns and some individual entries carry bibliographic references to indicate whether they came from primary sources. Estimates are footnoted as such. In some cases, a data entry has both a footnote and a bibliographic reference, which means an estimate is published.

Farm Real Estate Loan Data

First, consider the data on farm real estate loans outstanding. They are presented in table 1 as of January 1 for 1951 through 1977 for the five major lenders: Federal land banks, life insurance companies, commercial banks, the Farmers Home Administration, and individuals and others. Except for individuals and others, all data in table 1 originate from primary sources. The Farm Credit Administration for Federal land banks, the American Council of Life Insurance Companies (formerly the Institute of Life Insurance Companies) for life insurance companies, the Federal Deposit Insurance Corporation for banks, and the Farmers Home Administration all collect and report the data presented in this table.

The individuals and others series, the only one estimated in table 1, is supported by some primary data. Every fifth year, census benchmarks provide an opportunity to assess the error associated with the series and to make revisions. But data from the Census of Agriculture are known to be underreported, especially during recent censuses, which makes it a less reliable guide.

Table 1—Farm real estate loans outstanding by lender, January 1, 1951-77

Year	Total farm real estate debt[1]	Federal land banks	Life insurance companies	Farmers Home Administration	Commercial banks	Individuals and others[1]
				1,000 dollars		
1951	6,031,405	946,469(*8*)	1,352,635(*15*)	220,813(*8*)	985,954(*15*)	2,525,534(*15*)
1952	6,575,831	997,573(*8*)	1,541,874(*15*)	233,366(*8*)	1,017,360(*15*)	2,785,658(*15*)
1953	7,138,808	1,078,493(*8*)	1,716,022(*15*)	244,722(*8*)	1,069,398(*15*)	3,030,173(*15*)
1954	7,633,117	1,179,889(*8*)	1,892,773(*15*)	252,542(*8*)	1,091,949(*15*)	3,215,964(*15*)
1955	8,133,576	1,280,944(*8*)	2,051,784(*15*)	265,249(*8*)	1,161,308(*15*)	3,374,291(*15*)
1956	8,912,210	1,497,165(*8*)	2,271,784(*15*)	295,903(*8*)	1,275,429(*15*)	3,571,929(*15*)
1957	9,716,931	1,744,052(*8*)	2,476,543(*15*)	336,677(*8*)	1,298,113(*15*)	3,861,546(*15*)
1958	10,248,982	1,919,281(*8*)	2,578,958(*15*)	385,175(*8*)	1,315,530(*15*)	4,050,038(*15*)
1959	10,926,699	2,088,791(*9*)	2,661,229(*15*)	419,991(*9*)	1,407,548(*15*)	4,349,140(*15*)
1960	11,877,163	2,359,841(*9*)	2,819,542(*15*)	446,261(*9*)	1,523,051(*15*)	4,728,468(*15*)
1961	12,592,134	2,563,772(*9*)	2,974,609(*15*)	469,972(*9*)	1,591,762(*15*)	4,992,019(*15*)
1962	13,499,964	2,827,973(*9*)	3,161,757(*15*)	523,654(*9*)	1,640,790(*15*)	5,345,109(*15*)
1963	14,841,351	3,051,973(*9*)	3,391,183(*15*)	703,493(*9*)	1,870,216(*15*)	5,824,486(*15*)
1964	16,515,804	3,309,883(*9*)	3,780,537(*15*)	855,586(*9*)	2,136,571(*15*)	6,433,227(*15*)
1965	18,653,838	3,718,170(*9*)	4,287,671(*15*)	1,013,096(*9*)	2,416,634(*15*)	7,218,267(*15*)
1966	20,893,232	4,280,675(*9*)	4,801,677(*15*)	1,163,211(*9*)	2,607,404(*15*)	8,040,265(*15*)
1967	22,790,437	4,957,836(*9*)	5,213,587(*15*)	1,333,004(*9*)	2,770,010(*15*)	8,516,000(*15*)
1968	24,832,098	5,609,265(*9*)	5,539,600(*15*)	1,487,682(*9*)	3,060,551(*15*)	9,135,000(*15*)
1969	27,008,905	6,126,369(*9*)	5,763,500(*15*)	1,620,777(*9*)	3,333,259(*15*)	10,165,000(*15*)
1970	28,746,514	6,714,172(*9*)	5,733,900(*15*)	1,800,418(*9*)	3,545,024(*15*)	10,953,000(*15*)
1971	29,900,686	7,187,140(*9*)	5,610,300(*15*)	1,952,869(*9*)	3,772,377(*15*)	11,378,000(*15*)
1972	31,790,848	7,918,185(*9*)	5,564,300(*15*)	2,162,881(*9*)	4,218,482(*15*)	11,927,000(*15*)
1973	35,271,019	9,104,930(*9*)	5,643,300(*15*)	2,293,604(*9*)	4,792,185(*15*)	13,437,000(*15*)
1974	40,857,567	11,073,276(*9*)	5,964,800(*15*)	2,446,213(*9*)	5,458,278(*15*)	15,915,000(*15*)
1975	46,179,656	13,863,752(*9*)	6,297,400(*15*)	2,644,583(*9*)	5,966,282(*15*)	17,407,639(*15*)
1976	51,140,631	16,563,886(*9*)	6,726,000(*12*)	2,826,745(*9*)	6,296,000(*12*)	18,728,000(*12*)
1977	56,613,811	[2]19,126,749	7,400,000(*12*)	[2]3,040,062	6,781,000(*12*)	20,266,000(*12*)

[1] Estimate. [2] Preliminary.

Note: Italicized numbers in parentheses refer to items in the Bibliography at the end of this article.

Table 2—Annual totals of new farm real estate loans made by lenders, 1951-77

Year	Total farm real estate loans[1]	Federal land banks	Life insurance companies	Farmers Home Administration	Commercial banks	Individuals and others
	1,000 dollars					
1951	1,772,834	214,220(*8*)	407,000(*4*)	34,163(*8*)	458,422(*14*)	659,029(*14*)
1952	1,777,230	254,581(*8*)	372,000(*4*)	34,247(*8*)	483,677(*14*)	632,725(*14*)
1953	1,870,977	289,772(*8*)	428,000(*4*)	24,379(*8*)	483,990(*14*)	644,836(*14*)
1954	1,904,144	306,276(*8*)	413,000(*4*)	37,057(*8*)	500,080(*14*)	647,731(*14*)
1955	2,398,745	487,489(*8*)	515,000(*4*)	52,793(*8*)	582,001(*14*)	761,462(*14*)
1956	2,397,354	522,357(*8*)	514,000(*4*)	62,120(*8*)	527,949(*14*)	770,928(*14*)
1957	2,238,092	398,993(*8*)	407,000(*4*)	65,797(*8*)	502,726(*14*)	863,576(*14*)
1958	2,385,113	429,424(*8*)	438,000(*4*)	62,666(*8*)	554,913(*14*)	900,110(*14*)
1959	2,753,834	572,064(*9*)	496,000(*4*)	53,864(*9*)	605,380(*14*)	1,026,526(*14*)
1960	2,561,630	503,888(*9*)	464,000(*4*)	51,586(*9*)	541,022(*14*)	1,001,134(*14*)
1961	2,967,087	632,517(*9*)	552,000(*4*)	94,964(*9*)	623,318(*14*)	1,064,288(*14*)
1962	3,461,459	644,706(*9*)	619,000(*4*)	221,423(*9*)	732,934(*14*)	1,243,396(*14*)
1963	4,127,717	742,860(*9*)	866,000(*4*)	198,909(*9*)	880,351(*14*)	1,439,597(*14*)
1964	4,773,155	998,081(*9*)	1,047,000(*4*)	218,367(*9*)	994,628(*14*)	1,515,079(*14*)
1965	5,317,216	1,235,154(*9*)	1,149,000(*4*)	238,113(*9*)	1,036,524(*14*)	1,658,425(*14*)
1966	5,476,966	1,337,250(*9*)	994,000(*4*)	239,111(*9*)	1,055,992(*14*)	1,850,613(*14*)
1967	5,171,792	1,267,586(*9*)	837,000(*4*)	243,041(*9*)	1,036,109(*14*)	1,788,056(*14*)
1968	5,124,710	1,101,322(*9*)	772,000(*4*)	226,383(*9*)	1,134,051(*14*)	1,890,954(*14*)
1969	5,336,520	1,165,895(*9*)	540,000(*4*)	275,613(*9*)	1,069,867(*14*)	2,285,145(*14*)
1970	5,074,660	1,016,820(*9*)	314,000(*4*)	240,814(*9*)	1,063,728(*14*)	2,439,298(*14*)
1971	6,805,191	1,555,008(*9*)	503,000(*4*)	321,690(*9*)	1,516,582(*14*)	[2] 2,175,312
1972	[3] 8,454,510	2,251,035(*9*)	700,000(*4*)	345,199(*9*)	[3] 1,944,703	[2] 3,213,573
1973	[3] 11,399,900	3,284,680(*9*)	1,006,000(*4*)	387,985(*9*)	[3] 2,324,093	[2] 4,397,142
1974	[3] 11,618,200	4,243,479(*9*)	1,007,000(*4*)	364,979(*9*)	[3] 2,282,004	[2] 3,720,738
1975	[3] 11,771,603	4,411,268(*9*)	1,075,000(*4*)	355,161(*9*)	[3] 2,172,718	[2] 3,757,456
1976	[3] 13,471,908	[4] 4,700,861	[5] 1,540,000	496,299	[3] 2,575,000	[2] 4,159,748
1977	[3] [5] 17,232,005	[4] [5] 5,817,000	[5] 2,564,100	[5] 457,665	[3] [5] 3,532,000	[2] [5] 4,861,240

[1] Obtained by adding across lenders. [2] Unpublished ESCS data. [3] Estimate. [4] Unpublished Farm Credit Administration data. [5] Preliminary.

Note: Italicized numbers in parentheses refer to items in the Bibliography at the end of this article.

Fortunately, another primary data source can be used to estimate outstanding farm real estate debt held by individuals and others: sample data on new loans made from the Farm Real Estate Market Development survey. But the reliable loans made data are combined with a rather arbitrary assumption relating to repayments of debt by individuals and others, which suggests some improvements in the series are possible.

For Federal land banks, three different loans outstanding series are reported. ESCS publishes two and the Farm Credit Administration publishes a third (see *8*, *14*). Including or excluding Federal land bank loans in Puerto Rico largely accounts for differences between the two ESCS series. Meanwhile, the Farm Credit Administration's published series includes not only loans made in Puerto Rico but also some rural home loans. This report uses the series published by the Farm Credit Administration because it is consistent with their loans made and interest rate data which we use later.

Life insurance companies report two different data series on loans outstanding. One series reports farm mortgage loans outstanding for U.S. life insurance companies held by borrowers in both the United States and Canada while the other series excludes loans made by the companies to Canadian borrowers. The series reported in table 1, which is the same one reported by ESCS, excludes farm loans made in Canada by U.S. life insurance companies.

The Farmers Home Administration series in table 1 includes only direct and insured loans for farm ownership. The ESCS series includes other types of FmHA loans as well.

Table 2 contains a summary of new loans made by lenders. Only commercial bank data for 1973 through 1977 are estimates. Earlier, they had been based on the Farm Credit Administration's farm mortgage survey as had been the individuals and others series. But for individuals and others, the Farm Credit Administration survey data were supplanted with data from the Farm Market Real Estate Development survey. For the other lenders, the same sources that report loans outstanding also report loans made.

Finally, loans repaid and refinanced are estimated residually and reported in table 3. To obtain an estimate of repayments in year t (R_t) loans outstanding at the end of the year (L_{t+1}) are subtracted from loans outstanding at the beginning of the year (L_t) and then added to loans made during the year (N_t).[2]

$$R_t = L_t - L_{t+1} + N_t \tag{1}$$

To obtain the table of repayment ratios (ρ_t) reported in table 4, repayments during year t are divided by loans outstanding at the beginning of year t ($\rho_t = R_t/L_t$).

Farm Real Estate Interest Data

In general, interest rate data are based on fewer primary data than are the loan data. For example, the only average interest rates based on primary data are those reported for the Federal land banks. All other series (except for the FmHA rate which is set by law) are estimates (see table 6).

The average interest rate on new loans in table 5 is more reliable—based on more primary data than the average rate series. The Federal land bank series is based on primary data. For odd years before 1960, the life insurance company series are based on the Farm Credit Administration's surveys of farm mortgages recorded. Beginning in 1960, they are based on primary data collected and prepared by ESCS. The new loan rates for commercial banks and individuals (not the others part) for odd years up to 1971 are based on the Farm Credit Administration's farm mortgage survey. After 1972 the new rates for commercial banks and individuals (except for 1976) are based on survey data from the Farm Real Estate Market Development survey.

The method of estimation for those series not based on the primary data will be discussed in the following section. Since all the data in tables 7 and 8 are estimates, their derivations will also be discussed in the next section.

[2] This method of estimating loan repayments includes bad debts written off and loans in the process of foreclosure as part of repayments.

Table 3—Annual totals of new farm real estate loans repaid to lenders, 1951-77

Year	Total farm real estate loans[1]	Federal land banks[1]	Life insurance companies[1]	Farmers Home Administration[1]	Commercial banks[1]	Individuals and others[1]
	1,000 dollars					
1951	1,228,408	163,116	217,761	21,610	427,016	398,905
1952	1,214,253	173,661	197,852	22,891	431,639	388,210
1953	1,376,668	188,376	251,249	16,559	461,439	459,045
1954	1,403,685	205,221	253,989	24,350	430,721	489,404
1955	1,620,111	271,268	295,000	22,139	467,880	563,824
1956	1,592,633	275,470	309,241	21,346	505,265	481,311
1957	1,706,041	223,764	304,585	17,299	485,309	675,084
1958	1,707,396	259,914	355,729	27,850	462,895	601,008
1959	1,804,824	301,014	337,687	29,048	489,877	647,198
1960	1,846,659	299,957	308,933	27,875	472,311	737,583
1961	2,059,938	368,316	364,852	41,282	574,290	711,198
1962	2,119,391	420,706	389,574	41,584	503,508	764,019
1963	2,453,264	484,950	476,646	46,816	613,996	830,856
1964	2,635,121	589,794	539,866	60,857	714,565	730,039
1965	3,077,822	672,649	634,994	87,998	845,754	836,427
1966	3,579,761	660,089	582,090	69,318	893,386	1,374,878
1967	3,130,131	616,157	510,987	88,363	745,568	1,169,056
1968	2,947,903	584,218	548,100	93,288	861,343	860,954
1969	3,598,911	578,092	569,600	95,972	858,102	1,497,145
1970	3,920,488	543,852	437,600	88,363	836,375	2,014,298
1971	4,181,430	823,963	549,000	111,678	1,070,477	1,626,312
1972	4,974,339	1,064,290	621,000	214,476	1,371,000	1,703,573
1973	5,813,352	1,316,334	684,500	235,376	1,658,000	1,919,142
1974	6,296,111	1,453,003	674,400	166,609	1,774,000	2,228,099
1975	6,810,628	1,711,134	646,400	172,999	1,843,000	2,437,095
1976	7,998,728	2,137,998	866,000	282,982	2,090,000	2,621,748
1977	[2]9,231,349	[2]2,491,800	[2]1,264,100	[2]225,209	[2]2,413,000	[2]2,837,240

[1] Estimate. [2] Preliminary.

Table 4—Annual ratios of farm real estate loans repaid during year to loans outstanding at beginning of year, 1951-77

Year	All lenders[1]	Federal land banks[1]	Life insurance companies[1]	Farmers Home Administration[1]	Commercial banks[1]	Individuals and others[1]
1951	.204	.172	.161	.098	.433	.158
1952	.185	.174	.128	.098	.425	.139
1953	.193	.174	.146	.067	.431	.151
1954	.184	.174	.134	.096	.395	.152
1955	.199	.212	.144	.083	.403	.167
1956	.179	.184	.136	.072	.396	.135
1957	.176	.128	.123	.051	.374	.175
1958	.167	.135	.138	.072	.352	.148
1959	.165	.144	.127	.069	.348	.149
1960	.155	.127	.110	.063	.310	.156
1961	.164	.144	.123	.088	.361	.142
1962	.157	.149	.123	.079	.307	.143
1963	.165	.159	.141	.067	.328	.143
1964	.159	.178	.143	.071	.334	.113
1965	.165	.181	.148	.087	.350	.116
1966	.171	.154	.121	.060	.343	.171
1967	.137	.124	.098	.066	.269	.137
1968	.119	.104	.099	.063	.281	.094
1969	.133	.094	.099	.059	.257	.147
1970	.136	.081	.076	.049	.236	.184
1971	.139	.115	.098	.057	.284	.143
1972	.156	.134	.112	.099	.325	.143
1973	.165	.145	.121	.103	.346	.143
1974	.154	.131	.113	.068	.325	.140
1975	.147	.123	.103	.065	.309	.140
1976	.156	.129	.129	.100	.332	.140
1977	[2].163	[2].130	[2].171	[2].074	[2].356	[2].140

[1] Estimate. [2] Preliminary.

HOW THE DATA WERE ESTIMATED

Estimating Loans Outstanding and New Loans Made

Considering loans outstanding first, only those held by individuals and others requires estimation. ESCS analysts routinely estimate loans held by individuals and others (table 1).

Historically, the estimates have been based on primary data on loans made, obtained from the Farm Credit Administration's farm mortgage survey and, since 1971, from a USDA survey on loans made by individuals. However, the lack of reliable benchmarks on outstanding loans leaves the accuracy of this series somewhat questionable.

Repayment ratios calculated for each lender (table 4) offer evidence that the individuals and others loans outstanding data are less than reliable. Repayment ratios for lenders except individuals and others show significant positive correlation. The correlation between repayment ratios of individuals and others, however, is insignificant. Moreover, after 1971, the repayment ratio of individuals and others is assumed to be constant—a questionable assumption since all other series vary considerably year to year.[3]

The loans made data, as with the loans outstanding data, are based mostly on primary data (the publication source is shown for each in table 2). Only loans made by commercial banks after 1971 are estimated without the benefit of primary data.

To complete the loans made data, we regressed the repayment ratios for commercial banks $(\rho_{cb})_t$ on the weighted average of the loans repayment ratios of Federal land banks and life insurance companies ($\bar{\rho}_t$) over 1951-71:

[3] The simple correlations between the data on repayment ratios for commercial banks, life insurance companies, and Federal land banks ranged from 79 to 83 percent. The simple correlations of repayment ratios between individuals and others and commercial banks, life insurance companies, and Federal land banks were 0.11, −0.11, and 0.10, respectively.

Were the repayment ratios for individuals and others after 1971 equal to a weighted average of the Federal land banks and life insurance companies ratios, their loans outstanding for January 1, 1977 would have been $21.4 rather than the $20.3 million reported in table 1.

$$\rho_{cbt} = 0.0822 + 1.9414\,\bar{\rho}_t. \quad R^2 = 0.84. \tag{2}$$

Commercial bank repayment ratios for years after 1971 were then obtained by substituting each year's known value of $\bar{\rho}_t$ into this equation. The resulting estimated repayment ratio was next multiplied by loans outstanding at the beginning of the year, to obtain estimated repayments of commercial bank loans. Finally, we added loan repayments to the year's change in loans outstanding to obtain the amount of loans made: The procedure can be summarized as:

$$N_t = L_{t+1} - L_t + R_t \tag{3}$$

where:

$$R_t = (0.0822 + 1.9414\,\bar{\rho})\,L_t$$

Estimating Interest Rates

The new rate series in table 5 requires little estimation. For life insurance companies, only the new rate for even numbered years before 1960 need to be estimated. For commercial banks and individuals, the new rate for even numbered years before 1973 and the year 1976 need to be estimated. Since for each year in which estimates are needed, rates based on primary data precede and follow, the new rate estimate is simply an average of the two.

The average rates of interest on loans outstanding (table 6) are all estimates, except for those supplied by the Federal land banks. The reason for such widespread use of estimates is the difficulty of measuring the average rate. Logically, to find the average rate on outstanding loans would require that interest rates on all loans made and not repaid be recorded and weighted by that portion of the original loan outstanding as of some point in time. This measurement obviously is a task too big to be performed routinely. Thus, in practice, only periodic measurements of the average rate are taken, while those for interim years are estimated.

In the past, ESCS estimated the average rates between benchmarks by calculating a weighted average of the new rate and the average rate at the beginning of the

Table 5—Average interest rates on new farm real estate loans made by lender for years 1951-77

Year	Federal land banks	Life insurance companies	Farmers Home Administration[1]	Commercial banks	Individuals
			Percent		
1951	4.1(*8*)	4.3(*10*)	4.0	5.3(*10*)	4.9(*10*)
1952	4.2(*8*)	[2]4.5	4.0	[2]5.4	[2]5.0
1953	4.2(*8*)	4.8(*10*)	4.0	5.5(*10*)	5.0(*10*)
1954	4.2(*8*)	[2]4.7	4.0	[2]5.5	[2]5.0
1955	4.2(*8*)	4.6(*10*)	5.0	5.5(*10*)	5.0(*10*)
1956	4.3(*8*)	[2]4.9	5.0	[2]5.7	[2]5.1
1957	5.2(*8*)	5.2(*2*)	5.0	5.9(*2*)	5.2(*2*)
1958	5.2(*8*)	[2]5.3	5.0	[2]5.9	[2]5.3
1959	5.5(*8*)	5.3(*2*)	5.0	5.9(*2*)	5.4(*2*)
1960	6.0(*3*)	6.1(*3*)	5.0	[2]6.0	[2]5.5
1961	5.6(*3*)	5.9(*3*)	5.0	6.2(*16*)	5.5(*16*)
1962	5.6(*3*)	5.8(*3*)	5.0	[2]6.1	[2]5.5
1963	5.6(*3*)	5.8(*3*)	5.0	6.1(*16*)	5.5(*16*)
1964	5.5(*3*)	5.7(*3*)	5.0	[2]6.1	[2]5.4
1965	5.5(*3*)	5.8(*3*)	5.0	6.1(*16*)	5.4(*16*)
1966	5.8(*3*)	6.3(*3*)	5.0	[2]6.3	[2]5.5
1967	6.0(*3*)	6.7(*3*)	5.0	6.5(*16*)	5.7(*16*)
1968	6.7(*3*)	7.4(*3*)	5.0	[2]6.9	[2]6.0
1969	7.7(*3*)	8.5(*3*)	5.0	7.3(*16*)	6.2(*16*)
1970	8.7(*3*)	9.3(*3*)	5.0	[2]7.5	[2]6.4
1971	7.9(*3*)	8.6(*3*)	5.0	7.8(*16*)	6.5(*16*)
1972	7.4(*3*)	8.3(*3*)	5.0	[2]8.0	[2]6.9
1973	7.5(*3*)	8.6(*3*)	5.0	[3]8.2	[3]7.2
1974	8.1(*3*)	9.5(*3*)	5.0	[3]8.6	[3]7.5
1975	8.7(*3*)	10.0(*3*)	5.0	[3]8.8	[3]7.6
1976	8.7(*3*)	9.8(*3*)	5.0	[2]8.8	[3]7.7
1977	[4]8.4(*3*)	[4]9.3(*3*)	5.0	[3,4]8.9	[3,4]7.8

[1] Legal maximum rate which Farmers Home Administration can charge. [2] Estimate. [3] Unpublished ESCS Farm Market Real Estate Development survey data. [4] Preliminary.

Note: Italicized numbers in parentheses refer to items in the Bibliography at the end of this article.

Table 6—Average interest rates on farm real estate loans outstanding, by lender, January 1, 1951-77

Year	Weighted average for all lenders[1]	Federal land banks	Life insurance companies[1]	Farmers Home Administration[1]	Commercial banks[1]	Individuals[1]
	Percent					
1951	4.6	4.1(*13*)	4.3(*13*)	4.0	5.1(*13*)	4.6(*13*)
1952	4.6	4.1(*13*)	4.4(*13*)	4.0	5.2(*13*)	4.7(*13*)
1953	4.6	4.1(*13*)	4.4(*13*)	4.0	5.2(*13*)	4.7(*13*)
1954	4.7	4.1(*13*)	4.5(*13*)	4.0	5.3(*13*)	4.7(*13*)
1955	4.7	4.1(*13*)	4.5(*13*)	[3]4.2	5.3(*13*)	4.8(*13*)
1956	4.7	4.1(*13*)	4.6(*13*)	[3]4.3	5.3(*13*)	4.8(*13*)
1957	4.8	4.1(*13*)	4.6(*13*)	[3]4.4	5.4(*13*)	4.9(*13*)
1958	4.8	4.2(*13*)	4.7(*13*)	[3]4.5	5.5(*13*)	4.9(*13*)
1959	4.9	4.4(*13*)	4.8(*13*)	[3]4.6	5.6(*13*)	4.9(*13*)
1960	5.0	4.6(*15*)	5.0(*15*)	[3]4.6	5.7(*15*)	4.9(*15*)
1961	5.0	4.8(*15*)	5.1(*15*)	[3]4.7	5.8(*15*)	4.9(*15*)
1962	5.1	4.9(*15*)	5.2(*15*)	[3]4.8	5.9(*15*)	5.0(*15*)
1963	5.2	5.0(*15*)	5.3(*15*)	[3]4.8	6.0(*15*)	5.1(*15*)
1964	5.3	5.1(*15*)	5.4(*15*)	[3]4.9	6.0(*15*)	5.1(*15*)
1965	5.3	5.2(*15*)	5.5(*15*)	[3]4.9	6.0(*15*)	5.1(*15*)
1966	5.3	5.2(*15*)	5.5(*15*)	[3]4.9	6.0(*15*)	5.1(*15*)
1967	5.4	5.4(*15*)	5.6(*15*)	[3]4.9	6.0(*15*)	5.1(*15*)
1968	5.5	5.6(*15*)	5.7(*15*)	5.0	6.2(*15*)	5.2(*15*)
1969	5.6	5.7(*15*)	5.8(*15*)	5.0	6.3(*15*)	5.2(*15*)
1970	5.7	6.0(*15*)	5.9(*15*)	5.0	6.5(*15*)	5.3(*15*)
1971	5.9	6.4(*15*)	6.0(*15*)	5.0	6.7(*15*)	5.4(*15*)
1972	6.0	6.5(*15*)	6.2(*15*)	5.0	7.1(*15*)	5.5(*15*)
1973	6.2	6.6(*15*)	[2]6.3	5.0	7.4	[2]5.7
1974	6.5	7.0(*15*)	6.6	5.0	7.7	6.0
1975	6.9	7.8(*15*)	6.9	5.0	8.0	6.1
1976	7.1	8.2	7.2	5.0	8.3	6.1
1977	[4]7.2	[4]8.2	[4]7.6	5.0	[4]8.5	[4]6.2

[1] Estimate. [2] Revised. [3] Estimated using equation (4). [4] Preliminary.

Note: Italicized numbers in parentheses refer to items in Bibliography at the end of this article.

Table 7—Average interest rates on farm real estate loans outstanding, by lender and region, January 1, 1977[1]

Region	All lenders[2]	Federal land banks[2]	Life insurance companies[2]	Farmers Home Administration[2]	Commercial banks[2]	Individuals and others[2]
	Percent					
Northeast	7.46	8.25	7.86	5.00	8.63	6.59
Lake States	7.26	8.17	7.78	5.00	8.55	6.53
Corn Belt	7.41	8.17	7.78	5.00	8.55	6.53
Northern Plains	7.24	8.16	7.77	5.00	8.54	6.52
Appalachian	7.65	8.27	7.88	5.00	8.65	6.61
Southeast	7.80	8.28	7.88	5.00	8.67	6.62
Delta States	7.43	8.07	7.68	5.00	8.45	6.45
Southern Plains	7.24	8.07	7.68	5.00	8.45	6.45
Mountain	7.23	8.16	7.77	5.00	8.54	6.52
Pacific	7.19	8.05	7.67	5.00	8.42	6.43
Alaska	7.83	8.15	7.76	5.00	8.53	6.51
Hawaii	7.63	8.00	7.62	5.00	8.37	6.39
United States	7.38	8.17	7.78	5.00	8.55	6.53

[1] Data were estimated in this table from official USDA figures for average interest rates on outstanding loans and from loans outstanding, which are not necessarily the same in amount as those reported in tables 1 and 6. [2] Estimated.

Table 8—Interest charges on farm real estate loans outstanding, by region, 1972-76[1]

Region	1972	1973	1974	1975	1976
			1,000 dollars		
Northeast	113,087.328	134,966.192	166,206.944	194,494.176	210,660.672
Lake States	203,027.296	234,283.872	281,318.144	325,089.536	369,434.368
Corn Belt	455,550.976	524,481.536	613,522.432	725,680.384	855,681.792
Northern Plains	218,279.296	252,192.016	290,630.144	329,998.080	388,723.456
Appalachian	151,416.464	178,592.816	219,386.032	268,116.848	306,513.408
Southeast	146,825.648	180,423.488	230,411.296	280,788.992	309,178.112
Delta States	129,802.736	149,190.192	175,324.336	203,837.632	228,735.072
Southern Plains	207,056.624	250,586.896	307,414.784	354,630.144	392,582.912
Mountain	203,911.424	235,262.016	273,355.264	318,417.920	366,006.784
Pacific	250,016.176	289,466.624	348,012.032	408,369.664	459,189.760
Alaska	274.573	292.489	300.864	305.213	271.016
Hawaii	2,379.031	3,520.140	4,284.706	4,673.795	4,777.349
United States	2,081,626.110	2,433,257.730	2,910,166.270	3,414,401.790	3,891,754.240

[1] Data were estimated from official USDA figures on average interest rates on outstanding loans and from loans outstanding, which are not necessarily the same in amount as those reported in tables 1 and 6.

preceding period (*10, 11*). But after 1973, when a new rate from the farm mortgage survey was no longer available, ESCS discontinued publishing the average rates for lenders even though new rates from the Farm Market Real Estate Development survey and from the lenders themselves were available to maintain the series. We now integrate these new rates into estimates of average rates for lenders other than Federal land banks.[4]

As previously done by ESCS, the average rate on outstanding loans could be computed as a weighted average of the interest rate charged on new loans during the preceding period and of the average interest rate on loans outstanding at the beginning of the previous period. Logical choices for the weights are N_t/L_{t+1}, the percentage of loans outstanding which were made in earlier periods and not yet repaid. In equation form, the estimate would be:

$$\bar{r}_{t+1} = [r_t N_t + \bar{r}_t (L_t - R_t)]/L_{t+1} \qquad (4)$$

This method of estimation would be reliable if the average rate on loans repaid equalled the average rate on loans outstanding at the beginning of the period and not repaid. But it does not. Historically, loans with higher rates tend to be repaid faster than loans with lower rates. Thus, in place of $\bar{r}_t$ in equation (4), an estimate $\bar{\bar{r}}_t$, is required, which is the rate on loans outstanding at the beginning of the period and not repaid.

Logically, there should be a close relationship between $\bar{r}_t$ and $\bar{\bar{r}}_t$. To measure this relationship statistically, requires that values of $\bar{\bar{r}}_t$ be obtained. These values were solved for by replacing $\bar{r}_t$ by $\bar{\bar{r}}_t$ in (4). Since the only unknown is $\bar{\bar{r}}_t$, it can be solved using the expression below:

$$\bar{\bar{r}}_t = (\bar{r}_{t+1} L_{t+1} - r_t N_t)/(L_t - R_t) \qquad (5)$$

With values of $\bar{\bar{r}}_t$ thus obtained, the relationship between ($\bar{\bar{r}}_t$) and ($\bar{r}_t$) was measured statistically by regressing $\bar{\bar{r}}_t$ on $\bar{r}_t$ over 1951-71. The statistical relationships are:

$$\bar{\bar{r}}_t = 1.147\ \bar{r}_t^{\ .913} \qquad R^2 = .98 \qquad (6)$$

for life insurance companies.

$$\bar{\bar{r}}_t = .934\ \bar{r}_t^{\ 1.031} \qquad R^2 = .97 \qquad (7)$$

for commercial banks, and

$$\bar{\bar{r}}_t = 1.305\ \bar{r}_t^{\ .825} \qquad R^2 = .92 \qquad (8)$$

for individuals.

Now, the average rate can be found recursively beginning in 1973 by using the 1972 ESCS estimate of $\bar{r}_t$ to predict $\bar{\bar{r}}_t$ which can then be used to estimate $\bar{r}_{t+1}$. Then $\bar{r}_{t+1}$ can be used to estimate $\bar{\bar{r}}_{t+1}$, and so on. Thus, in a recursive manner, we estimated the average rate on outstanding loans using primary data on new loans, the new interest rate, loans outstanding, and a statistical relationship between the average interest rate estimated by ESCS and a calculated number for the average rate on loans carried over from the previous year.

[4] The new rates reported in table 5 are, for the most part, contractual rates of interest. The actual cost of loan funds available to the borrower may be somewhat higher. For example, Federal land bank borrowers are required to purchase stock in the Federal land banks with part of their loan, making their effective rate higher than their contractual rate reported in table 5.

Estimating Interest Charges

The amount of interest charged was estimated from the data on outstanding loans and average rate data by lender. Loans outstanding at the end and beginning of a period were multiplied by one-half the average rates in effect at the beginning and end of the period, and the results were added.

State level interest charges to be used in State farm income estimates required that some efforts be made to disaggregate the national level interest charge figures. This requirement, of course, placed a great strain on the existing data base. Average interest rates are available by State only for Federal land banks, but this provides a key for estimating State-level interest charges for other lenders.

First, we obtained a State weight equal to the average State rate divided by the average national rate for Federal land banks. Using this weight, we estimated an interest charge for each lender by State by multiplying the national average rate for lenders other than Federal land banks by each of the 50 State weights.

Next, the beginning and end of period average State rates (by lender) were divided by two and multiplied by beginning and end of period outstanding loans in each State and then added. In addition, by summing the interest charges and dividing by the average level of outstanding loans over the period, we obtained an all-lender rate for the period. Regional estimates of interest charges and regional average rates are summarized in tables 7 and 8.

CONCLUSIONS

Farm real estate finance data are available from a wide variety of published and unpublished sources. We have collected these data, provided estimates where needed, and reported the results in a way that distinguishes estimates from primary data. Research relating to the farm real estate loan market should benefit not only from having this data available in one place but also from having the distinction made clear from primary data and estimates. This distinction is important for researchers who model the farm finance market because, to the extent possible, relationships examined should be explored using primary data.

In some cases, estimates must be used. For example, ESCS must supply data on interest charges on farm loans, but lacks the necessary primary data to do so. So average rates, a key variable in the calculation of interest charges, are estimated. We discussed a method for making estimates of average rates and how these estimates are used by USDA to calculate interest charges.

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HOW COTTON ACREAGE, YIELD, AND PRODUCTION RESPOND TO PRICE CHANGES

By Sam Evans and Thomas M. Bell*

THE QUESTION

How does an increase in the farm or support price of cotton affect its total production? This question is usually answered in two steps. First, a change in acreage harvested is estimated, and second, the acreage change is multiplied by an estimated average yield. Average yield is typically estimated by some technique such as trend, moving averages, last year's yield, and so forth.

▲ Regional upland cotton acreage and yield response equations were estimated by ordinary least squares. Cotton production response to price is shown to depend upon the relative responses of acreage to price, yield to price, and yield to acreage. Examples appear of ways the analysis may be used to help policymakers decide on price support and acreage control levels. Traditionally, percentage changes in acreage have been equated with percentage changes in production. However, it is shown that a 13-percent change in cotton acreage harvested may be required to change production by 10 percent.

▲ Keywords: Cotton, acreage and yield response, price, weather, region, elasticity, ordinary least squares.

However, Houck and Gallagher, among others, have demonstrated that some factors affecting acreage planting decisions, especially price, also significantly influence average yield. Ignoring the interdependencies between acreage and yield responses may lead to serious errors in estimating total production response (acreage times yield) to changes in key variables.

An Approach to the Solution

We present equations to explain variations in upland cotton acreages and yields in the major producing regions. These equations will be used to illustrate the intricacies of estimating total production response to economic and other variables. The results strongly suggest that analysis of yield response to economic and policy variables should be given increased attention in evaluating total production response.

Theoretical Basis

Following Houck and Gallagher, we express the production function (for cotton) as:[1]

$$Q = f(HA, I) \tag{1}$$

Cotton production is shown as a function of harvested acreage (HA) and the quantities of inputs (I), such as fertilizer, applied per acre. The acreage decisions are influenced by net returns from cotton relative to those from competing crops, Government programs, and so forth.

Suppose producers decided to plant A_o acres of cotton (harvested HA_o acres). Economic theory suggests an aggregate supply function of the form:

$$Q = g(P/PI, HA_o) \tag{2}$$

i. which cotton output (Q) is a function of cotton price (P), prices of variable inputs (PI), and the land input (HA_o).

A yield per acre function can be derived from (2):

$$Y = Q/HA_o = h(P/PI, HA_o) \tag{3}$$

We expect the relation between Y and P/PI to be positive, assuming that producers seek to maximize profits. Yet we expect a negative relationship between Y and HA since increases in cotton acreage involve bringing marginal land into production. Decreases in cotton acreage will lead to a higher average yield because marginal land moves out of cotton production.

Production Response to Price

To estimate production we use a system of two behavioral equations and an identity:

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[1] Houck, J. P. and Paul W. Gallagher. "The Price Responsiveness of U.S. Corn Yields." *American Journal of Agricultural Economics* 58, No. 4, November 1976: 731-734.

$$HA = a(P, ZA)^2 \quad (4)$$

$$Y = y(P, HA, ZY) \quad (5)$$

and the identity is:

$$Q = HA \cdot Y \quad (6)$$

Previously undefined variables ZA and ZY embody all other factors affecting the levels of harvested acreage and average yield, respectively.

The total differentials of the system are (ignoring the Z's, for simplicity):[3]

$$dHA = a_p dP \quad (7)$$

$$dY = y_p \cdot dP + y_{HA} \cdot dHA \quad (8)$$

and

$$dQ = Y \cdot dHA + HA \cdot dY \quad (9)$$

Using Cramer's rule, we solve for $\frac{dQ}{dP}$ and find:

$$\frac{dQ}{dP} = HA \cdot y_p + HA \cdot y_{HA} \cdot a_p + Y \cdot a_p \quad (10)$$

Multiplying through by P/Q, we derive the production elasticity for price (and with some algebraic manipulations):

$$E_{Q/P} = E_{Y/P} + E_{Y/HA} \cdot E_{HA/P} + E_{HA/P}$$

$$= E_{Y/P} + E_{HA/P} (1 + E_{Y/HA}) \quad (11)$$

$E_{Q/P}$, $E_{Y/P}$, and $E_{HA/P}$ are the elasticities of production, yield, and harvested, respectively, for price. $E_{Y/HA}$ is the elasticity of yield for harvested acreage.

The response of production to price, therefore, depends upon the relative responses given above. All we know *a priori* is that $E_{Y/P}$ and $E_{HA/P}$ are positive and $E_{Y/HA}$ is negative. If $E_{Y/P}$ equals 0, $E_{Q/P}$ will always be less than $E_{HA/P}$. If $E_{Y/P}$ exceeds 0, $E_{Q/P}$ may be greater or less than $E_{HA/P}$.

The implication is that policymakers, to achieve desired production increases or decreases, must be aware of the relative responses contained in expression (11). For example, if $E_{Y/HA}$ were large relative to $E_{Y/P}$, a cut in acreage of 15 percent might be required to achieve a 10-percent reduction in production. Finally, policymakers and economists need also to be cognizant of regional differences in the response of production to changes in economic and policy variables. We now show what happens regionally to cotton production, testing our equations by changing certain economic and policy variables.

RESULTS

Cotton acreage and yield equations were estimated for four producing regions in the United States by ordinary least squares with data for 1959-76 cotton crop years and 1951-74 crop years. For significant variables, the acreage equations were virtually identical across regions. However, the yield equations differed. The basic regional yield equation expressed yield as a function of deflated cotton price, harvested acreage, rainfall and temperature variables, acreage planted in "skip-row" patterns, and a time trend to account for technological change.

Obviously, the weather variables differ because of cotton's widespread geographical area.

Trends in cotton yields were similar in the Delta and Southeast. No discernible trend was evident in the Southwest while the Western region exhibited a significant trend effect in only the early to mid-fifties. Deflated cotton price had a significant effect in the Southeast and Western yield equations, but not in the Delta and Southwest. In the Southwest, an area of relatively low cotton yields, producers apply fertilizer and other inputs less intensively than producers elsewhere. Thus, the insignificant price variable was not unexpected.

REGIONAL RESPONSES OF COTTON ACREAGE

The general form of the acreage response equations with expected signs is:[4]

$$A_i = a_0 + a_1 PCT_i - a_2 AVOC_i - a_3 DIV_i$$

$$+ a_4 DP_i + a_5 ALOT_i + e \quad (12)$$

where:

i = U.S. total, or one of the four producing regions

A_i = planted acreage of upland cotton, thousands of acres

PCT_i = average farm price of upland cotton, cents per pound, January through April of current calendar year

$AVOC_i$ = the sum of the average variable and opportunity costs of growing cotton, cents per pound

[2] Harvested acreage is expressed as a function of planted acreage (A):HA = f (A), and A = a (P, ZA).

[3] We thank Keith Collins, an agricultural economist with the Commodity Economics Division, ESCS, for suggesting this exposition.

[4] Evans, R. S. "Regional U.S. Cotton Acreage Response." *Cotton and Wool Situation*, CWS-11, Econ. Res. Serv., U.S. Dept. Agr., July 1977.

DIV_i = payment for diverting cotton acreage weighted by acreage eligible for diversion, cents per pound

DP_i = direct or deficiency payment for producing cotton weighted by acreage eligible for support, cents per pound

$ALOT_i$ = upland cotton acreage allotment, 1959-70, lagged acreage thereafter, thousands of acres

e = random error term

Average Variable and Opportunity Costs

The average variable and opportunity costs of producing upland cotton were calculated as follows:

$$AVOC_i = \frac{(P_i)(Y_i) - VC_i + VCC_i}{YC_i} \qquad (13)$$

Where:

i = one of four cotton production regions

P_i = expected farm price of a competing crop, January through April average of current calendar year—or announced support price, whichever is greater

Y_i = expected yield of a competing crop, per harvested acre

VC_i = expected production costs of a competing crop, dollars per harvested acre

VCC_i = expected costs of producing cotton less ginning costs, dollars per harvested acre

YC_i = expected yield of cotton lint, pounds per harvested acre

The variable, AVOC, identifies the price farmers must get for their cotton for returns above variable costs from cotton to equal those from alternative crops. The cotton acreage response curve (to cotton price) will shift to the left as AVOC increases and to the right as AVOC decreases.

Values of AVOC were calculated for the four major cotton producing regions; we assumed producers' expected yield would equal averages of the previous 3 years. Regional production cost estimates were obtained from USDA's Cost of Production Surveys for the 1974-76 crop years. Estimates for earlier years were made by adjusting the 1976 costs by USDA's "Index of Prices Paid For Production Items, Interest, Taxes, and Wage Rates."

Competing crops analyzed were: (a) soybeans in the Delta States of Arkansas, Louisiana, Mississippi, Missouri, and Tennessee; (b) corn and soybeans, equally weighted in the Southeastern region, consisting mainly of Alabama, Georgia, North Carolina, and South Carolina; (c) grain sorghum, used as cotton's chief competitor for the Southwestern States of Texas and Oklahoma; and (d) barley, used for the Western States of California, Arizona, and New Mexico.

Policy Variables

The national acreage response equation and each regional equation contain three policy variables: allotment acreages (ALOT); a diversion payment variable (DIV), and a direct payment variable (DP).

The allotment set an upper limit on acreage during the years in which marketing quotas were in effect (1959-70 in our study). However, since 1971, the allotment has served chiefly as a payment base rather than an acreage restriction. For the 1971-76 crop years, lagged acreage was used as a proxy for an upper limit.

The direct and diversion payments vary directly with the amount of the payments per pound and the acreage eligible for payments. Other things equal, cotton acreage would be expected to vary inversely for diversion payments and positively for direct payments. The equations were first estimated with direct payments as a separate variable. Because of the closeness of the coefficients on this variable and on the cotton price variable, the equations were reestimated with price and direct payments combined (except for the Delta).

The formula used to calculate the diversion and direct payment variables is given below:

$$\text{DP or DIV} = \frac{B \cdot V}{W} \qquad (14)$$

where:

DP = weighted direct payment, cents per pound

DIV = weighted diversion payment, cents per pound

B = acreage eligible for direct or diversion payments

W = weighting factor (16.2 million acres, U.S. allotment for 1964-69 crop years)

V = payment rate, cents per pound.

Equations

Estimated cotton acreage response equations appear in table 1. Generally speaking, the signs of the estimated coefficients are consistent with prior expectations, the estimated coefficients are large relative to their standard errors, and the high R^2's indicate the model's adequacy in explaining historical variations in planted cotton acreage.[5]

COTTON YIELD RESPONSE

Cotton yields are affected by weather, and economic, cultural, technological, and environmental factors.[5]

[5] Dudley, G. E., J. R. Donald, and R. G. Barlowe. "Yield and Acreage Implications for U.S. Cotton." *Cotton Situation*, CS-247, Economic Research Service, U.S. Department of Agriculture, August 1970.

Table 1—Regressions with cotton acreage as dependent variable, 1959-76

Equation	Constant	ALOT	PCT + DP	PCT	DP	DIV	AVOC	R^2	S.E.	D.W.
Delta	2,128	0.416		91	49	−580	−90	0.89	253	2.22
t-value	(2.4)	(3.3)		(5.5)	(2.0)	(7.3)	(7.2)			
Southeast	199	0.739	32			−347	−27	0.94	169	1.86
t-value	(0.4)	(9.5)	(3.3)			(6.4)	(3.6)			
Southwest	2,915	0.499	46			−839	−46	0.96	255	2.06
t-value	(4.2)	(7.5)	(3.1)			(11.0)	(4.6)			
West	374	0.453	28			−123	−23	0.90	79	1.84
t-value	(2.6)	(5.4)	(6.2)			(5.1)	(4.5)			

Note: Variables defined in text; acreage in thousands; S.E. = standard error and D. W. = Durbin-Watson test value.

Economic Factors

Changes in prices and production costs have both positive and negative impacts on cotton yields. For example, if higher cotton prices were expected, producers would increase the use of fertilizer and other yield-boosting inputs. They would also increase acreage planted to cotton, which would affect yield adversely as inferior (cotton) land comes into production.

In the Delta region, greater cotton acreage usually means more planted in mixed or heavy soils markedly less suited for cotton than are the finer soils. In the Southwest region, increased cotton acreage is highly correlated with increased nonirrigated acreage. Cotton yields on such acreage may be 1/3 to 1/2 lower than on irrigated acreage.

Weather Variables

Weather significantly influences cotton yields. They are susceptible to drought, excessive rainfall, and temperature extremes, especially freezing temperatures in autumn. Insect damage and weather are also related; for example, warm wet weather increases the likelihood of insect damage.

No completely satisfactory method of incorporating weather variables in yield response functions has been developed to date. We attempted it as follows: Monthly rainfall and temperature observations at weather reporting stations within subregions roughly corresponding to the USDA's Crop and Livestock Reporting Districts were obtained for 1951-74. Rainfall and temperature were expressed in mean deviation form (acre inches and degrees Fahrenheit) for each phase of the cotton planting and harvesting season.[6] These data were then aggregated to the regional level by weighting each subregion by its share of total harvested cotton acreage within the region.

[6] Preplanting, January-March; planting, April-May; growing, June-July; maturing, August-September; and harvesting, October-December.

Cultural Factors

The most important cultural practice affecting yields has undoubtedly been the planting of cotton in "skip-row" patterns. Alternating rows of cotton with strips of idle land increases yields by allowing more sunshine to reach the plants and by giving them additional room in which to grow and mature. Yields are computed on a cotton acre rather than a land acre basis.

Equations

The reported equations represent the "best" of the several specifications estimated per region.

Delta

The estimated yield equation is (*t*-values in parentheses):

$$
\begin{aligned}
Y = \underset{(2.9)}{428} &- \underset{(2.3)}{34HA}\ \underset{(2.8)}{3\,9.1TI} + \underset{(1.2)}{11.1T2} \\
&+ \underset{(1.9)}{0.155SKIP} - \underset{(1.7)}{23RAINOND} \\
&- \underset{(2.7)}{238D74} \qquad (5)
\end{aligned}
$$

where:

Y	=	yield of cotton lint, pounds per harvested acre
HA	=	harvested acres, millions
TI	=	1, 2, ---, 15, representing trend in Delta yield from 1951-65; 0 elsewhere

T2	=	1, 2, ---, 9, representing trend in Delta yield from 1966-74; 0 elsewhere
SKIP	=	acres of cotton planted in skip-row planting (two or fewer rows skipped), thousands of acres
RAINOND	=	departure from normal of Delta rainfall during harvest season, in acre-inches
D74	=	0, 1 variable to account for subnormal temperature in the fall of 1974.

The equation explained 79 percent of the variability in Delta yields over the historical period, with a standard error of 49 pounds. The coefficients are easily interpreted. For example, a 1-million acre increase in harvested acreage will cause per acre yield to decline 34 pounds; 100,000 acres planted in skip-row patterns (2 or less rows skipped) will lead to a 15.5-pound per acre increase. Rainfall averaging 1 acre-inch above normal in the fall will cause average yields to decline 23 pounds per acre.

Southeast

The estimated yield equation is:

$$\underset{(1.6)}{Y = 179} + \underset{(1.7)}{6.2PCT/INC} - \underset{(2.3)}{26HA} + \underset{(3.7)}{8.0TI} + \underset{(2.0)}{10.0T2} + \underset{(1.4)}{12.4SUMRAIN} \qquad (6)$$

where previously undefined variables are:

PCT	=	cotton farm price, January-April, cents per pound
INC	=	index of production costs in the region, 1967 = 1.0
SUMRAIN	=	departure of rainfall in the region from normal during growing season, acre-inches.

The equation explained 72 percent of the variation in Southeastern cotton yields during 1951-74, with a standard error of 27 pounds. Southeastern yields are responsive to changes in the deflated price of cotton. At approximately current price and cost levels, an increase of 5 cents per pound in cotton price would lead to an estimated yield increase of 3-1/2 pounds per acre.

Southwest

The estimated yield equation is:

$$\underset{(28.9)}{Y = 457} - \underset{(11.4)}{22HA} + \underset{(5.3)}{0.035SKIP} + \underset{(3.3)}{24RAINJFM} + \underset{(2.7)}{11RAINJJ} - \underset{(8.2)}{99SWFREZ} \qquad (7)$$

where previously undefined variables are:

RAINJFM	=	departure from normal of Southwestern rainfall during January-March, acre-inches
RAINJJ	=	departure from normal of Southwestern rainfall during June and July, acre-inches
SWFREZ	=	0, 1 variable to account for subnormal temperatures in the region in 1969-71 and 1974.

The equation explained 95 percent of the variation in Southwestern cotton yields during 1951-74, with a standard error of 18 pounds. The importance of preplanting period moisture (RAINJFM) is emphasized—yield changes by 24 pounds per each acre-inch above or below normal. A 1-million increase in harvested acreage is estimated to drop yield 22 pounds.

West

The yield equation is:

$$\underset{(0.3)}{Y = 56} + \underset{(2.3)}{8.4PCT/INC} + \underset{(6.8)}{93TW} + \underset{(2.8)}{0.255SKIP} - \underset{(2.6)}{126WEFREZ} \qquad (8)$$

where the previously undefined variables are:

TW	=	1, 2, ---, 6, trend in Western yields 1951-55; held constant, thereafter
WEFREZ	=	0, 1, variable to account for subnormal temperatures in 1969-71

This equation explained 83 percent of the variation in Western cotton yields, with a standard error of 60 pounds. Unlike behavior in the other regions, harvested acreage had no influence on yields, probably because acreage is virtually all irrigated.

IMPLICATIONS

Cotton production response to price has been shown to depend upon the relative responses of acreage to price, yield to acreage, and yield to price; see expression (11). Desired increases or decreases in output of cotton (or other crops) may be stimulated by Government policy. Acreage levels can be changed through increases or decreases in the support price (if production decisions are based on these, rather than market prices), or through policies to take land out of production such as the set-aside programs.

Knowledge of the responses embodied in expression (11) and of their regional differences will help policymakers decide on changes in support prices or, for example, the levels of cropland setaside percentages necessary to achieve production goals. Moreover, knowledge of these relationships should help economic analysts in forecasting and analyzing cotton production response to economic and policy variables.

Estimated Relationships

In table 2, values of EQ/P, $E_{HA/P}$, and EY/HA are presented. These elasticities apply to average cotton price, yield, harvested acreage, and production for the 1973-77 crop years.

To achieve a 10-percent decrease in regional production, required acreage cuts ($10 \div E_{Q/HA}$) would range from 10 percent in the West to 15 percent in the Southwest. A flat 10-percent cut in acreage across regions would lower total production only 8.1 percent, based on regional shares of production during the past 5 years. To reduce output 10 percent, cuts in acreage of about 13 percent would be required.

If economic conditions were such that cotton producers were basing their production decisions on support prices, what percentage increase in cotton's support price would be required to induce a 10-percent increase in production? The values of $E_{Q/P}$ indicate that a 10-percent increase in the support price would lead to production increases from just 2.2 percent in the Southwest to 19.5 percent in the Southeast. However, over the past 5 years, the Southwest has produced about 34 percent of the U.S. total, while the Southeast has produced just 8 percent (Delta, 28 percent; West, 26 percent). Based on regional shares of production, the U.S. value of $E_{Q/P}$ is estimated to be 0.84.

To achieve a 10-percent increase in production, a price increase of 12 percent is thus required. Traditionally, this type of question has been answered by estimating the price increase required to raise acreage 10 percent because of the assumed equivalency of percentage changes in acreage and production. However, a 13.2-percent increase in support price would be needed to increase acreage 10 percent since the value of $E_{HA/P}$ for the United States is 0.76. Such a price increase would expand production an estimated 11.1 percent (0.84 times 13.2), slightly above the target value of 10 percent.

Table 2—Relationships between cotton production acreage, yield, and price, by region[1]

Region	$E_{Q/P}$	$E_{Y/P}$	$E_{HA/P}$	$E_{Y/Ha}$	$E_{Q/HA}$[2]
Delta	0.87	[2]0	1.16	−0.25	0.75
Southeast	1.95	0.67	1.36	−0.06	0.94
Southwest	0.22	[2]0	0.33	−0.34	0.66
West	1.22	0.33	0.89	[3]0	1.00

[1] 1973-77 base; relationships defined in text. [2] $E_{Q/HA} = 1 + E_{Y/Ha}$. [3] Variable was insignificant in the yield equation.

In Earlier Issues

Soil scientists have found that on many soils the expected yields are closely related to the depth or thickness of the topsoil that is present. Further reductions in the depth of topsoil in such instances will have a predictable effect on the yields. The value of topsoil in terms of crop yields will vary, depending on the type of subsoil and the parent material. Then there are some soils, especially in the Southeastern States, in which the subsoil has a better capacity for holding moisture and fertilizer than has the present topsoil; in such cases the loss of topsoil may even increase productivity. But these cases are the exception. Most of the results of experimental studies in the Northern States indicate that crop yields decrease as topsoil is lost and that the decrease in yields per inch of topsoil loss usually increases as additional inches of topsoil are eroded away.

George H. Walter
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FEED DEMAND IN THE WORLD GOL MODEL

By Donald W. Regier*

▲ Agricultural commodity projections for 1985, developed by USDA's Economics, Statistics, and Cooperatives Service, show that the livestock sector acts as a large secondary grain reserve. A mathematical model of the combined world grain-oilseed-livestock (GOL) economy generates consistent projections of world commodity trade and prices, and regional production and consumption. The article presents analysis of the tie between crop and livestock sectors, located mainly in the developed countries. The focus is on the synthesis of feed demand equations containing input-output coefficients and price elasticities sensitive to both livestock products and feeds.

▲ World projections; agricultural commodities; livestock products; livestock feed; grain; oilseeds; mathematical model.

INTRODUCTION

Agricultural commodity projections for 1985 developed by USDA's Economics, Statistics, and Cooperatives Service (ESCS), imply that the world livestock sector acts as a large, secondary grain reserve. Located mainly in the developed countries, the sector appears to act as a governor, or stabilizer, for adjusting regional rates of world production and consumption and prices of grain by regulating livestock production and feeding. The World GOL Model (combined grain-oilseed-livestock sectors), developed by ESCS and in use since 1974, generates consistent longrange projections of international commodity trade, world prices, and regional world production and consumption.

In this article, I analyze the tie between crop and livestock sectors in the model, focus on the role of feed demand, and consider the linkages between the feed and livestock sectors. I conclude with some broad implications of the design of the feed equations and their role in the model.

THE WORLD GOL MODEL

The World GOL Model projects by region the crop areas, quantity of supply and distribution, net trade, and prices for each of 14 commodities basic in the feed-livestock complex: wheat, coarse grain (including corn), rice, oilmeal, soybeans, beef and veal, pork, poultry, mutton, milk, butter, and cheese.[1] The world is divided into 28 regions including a residual, and they are not symmetrically modeled. There are crop equations for all regions but not necessarily all crops. To date, there are livestock equations for only half the regions. There are reduced-form net trade equations for regions that contain the Centrally Planned countries. The U.S. sector is intended to be representative only; full U.S. models are used along with GOL in the ongoing ESCS projections program.[2] A total of 930 dependent variables is projected in a 930-equation system.

Within a region, the GOL model consists of eight major blocks of equations.

1—Demand: Livestock products
2—Supply: Livestock products
3—Demand: Crops for feed
4—Demand: Crops for food
5—Supply: Crops
6—Price linkages
7—Regional equilibrium
8—World equilibrium

The concern here is the structure of block 3, the demand for crops for feed. Feed demand is considered under two basic circumstances: first, when blocks 1 and 2, demand and supply of livestock products, are present in the model; and second, when they are absent.

ROLE OF FEED DEMAND

Postulating a quantified livestock production function and deriving both livestock supply and feed demand functions from it was seriously considered in the planning

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[1] The World GOL Model was developed in ESCS primarily by Anthony S. Rojko, Program Leader; Donald W. Regier, livestock and derived feed; Patrick M. O'Brien, grains; Arthur L. Coffing, oilseeds; Robert D. Barry, rice; Myles J. Mielke, dairy; and Linda M. Bailey, statistical and computer effort. People who have contributed to the development of the computer programs include Francis S. Urban and Roger P. Strickland, Hilarius Fuchs during the main development stage, followed by Fenton Sands and Martin W. Schwartz.

[2] First use of the model in projections appears in (*4*), followed by (*21*). The model's broad characteristics are discussed in (*24*), and it is presented comprehensively in (*25*, *26*, *27*, and *18*). The projection focus shifts from 1985 to 2000 in (*23*). Note: Italicized numbers in parentheses refer to items in References at the end of this article.

For treatment of U.S. models whose domestic detail integrates with GOL world trade projections, see (*12*, *15*, *16*, *29*).

stages for the GOL model. Arguments in favor of this approach are simplicity and mathematical elegance. The logic from production theory is straightforward and internal consistency of the resulting model is assured.

Because of difficulties in implementing such an approach, however, planners decided to use various sets of internationally comparable information that reveal important aspects of production processes used. A function responsive to price and technological development was postulated by region, for production of each important livestock commodity (block 2). Also, composite regionwide functions for feed grain and oilmeal demand were adopted, each with physical and price aspects (block 3). (See table 1 for the feed demand functions.)

Table 1—Equation forms for livestock feed demand, World GOL Model

Block 3		
• Feed grain demand	=	F(production, beef, pork, poultry, milk; prices of beef, pork, corn, oilmeal)
	+	G(per capital income, population, changing tastes, productivity growth, policy factors)
• Feed wheat demand	=	F(feed grain demand; prices of wheat, corn)
	+	G(productivity growth, policy factors)
• Feed corn demand	=	Feed grain demand
	–	Feed wheat demand
• Feed oilmeal demand	=	F(production: beef, pork, poultry, milk; prices of beef, pork, corn, oilmeal)
	+	G(per capita income, population, changing tastes, productivity growth, policy factors)

Note: F( ) indicates linear functions of endogenous variables.
G( ) indicates unrestricted functions of exogenous variables.

LINKING CROP AND LIVESTOCK SECTORS

The link between crop and livestock sectors of the World GOL Model is importantly physical. The quantity of a commodity demanded as feed is a weighted sum of the livestock commodities produced in a region; the weights are the amounts of feed used in producing each livestock product. The final sum is adjusted, as shown below, by price considerations. Calculations of grain used as feed are made, first, in total, and, second, apportioned into feed demand for wheat and for coarse grain. Oilmeal is analyzed similarly. Use of rice as feed is ignored at this stage because of data problems. The equation pattern for feed demand (block 3) is shown in table 1, where F is a matrix of linear functions of endogenous variables and G is a set of exogenous, independently projected factors.

Like demand functions generally, demand for feed is related to a set of direct- and cross-price elasticities. It is also related to physical production of endogenous livestock products by a set of input-output coefficients expressing tons of grain or meal used to produce a ton of livestock product. Price terms and input-output rates are F-functions. G-functions include factors such as technological change or policy considerations which affect use of grain or meal as livestock feed. They also include per capita income and population to account for demand in those parts of the livestock sector which are not yet modeled in the interactive part of GOL.

THE FEED-LIVESTOCK BALANCE

In the base from which projections are made—1970 or a span of years centered on 1970—the quantities of livestock commodities produced are balanced with the quantities of feed imputed to the use of each kind of animal product. Balancing (budgeting) is done in the light of limited information on feed conversion rates for different livestock products, different farming systems, and different practices in each of the 28 regions. Balances such as those shown in table 2 explicitly identify use rates (input-output ratios) for both grain and oilmeal, expressing tons of grain (or meal) used in producing a ton of livestock product. Such balances for each region are used for obtaining input-output ratios incorporated into the feed demand equations. The ratios are adjusted to account for the grain or meal reported as livestock feed in each region. Their regional variation constitutes a major asymmetry of the World GOL Model.

CONSTRUCTION OF INPUT-OUTPUT COEFFICIENTS

Input-output rates in the model are not in terms of feed used per unit of time but of the quantity used per unit of product. Feeds were budgeted in the base 1970 period, to account for the livestock products of the region in terms of the entirety of grains and oilmeals. Discrepancies encountered led either to (1) a second round of coefficient estimation or (2) a projection procedure respecting the coefficients and treating the discrepancy term explicitly in the projections (table 2). The input-output rates were studied in a time perspective and allowance for change was made in the projected rates.

The observed input-output coefficients for conversion of feed into livestock commodities are behavioral relationships depending on (1) biological considerations, (2) local climate and plant ecologies, (3) local production systems, and (4) the affluence of the agriculturist

Table 2—Livestock production and use of grain and meal as feed, European Economic Community, 1970

Livestock production		Grain use as feed		Oilmeal use as feed	
Product	Amount[1]	Use rate[2]	Amount[3]	Use rate[2]	Amount[3]
	Mil. mt	*Rate*	*Mil. mt*	*Rate*	*Mil. mt.*
EC-6:					
Meat	13.000	(2.278)	29.616	(.490)	6.364
Beef	4.416	1.300	5.741	.160	.707
Pork	5.061	3.600	18.220	.670	3.391
Poultry	1.920	2.700	5.184	1.180	2.266
Mutton	.195	.250	.049		
Other	1.408	.300	.422		
Other					
Milk	71.448	.130	9.288	.034	2.429
Eggs	2.492	3.100	7.725	.710	1.769
Total	(13.000)	(3.587)	46.629	(.812)	10.562
EC-3:					
Meat	4.500	(2.844)	12.797	(.420)	1.891
Beef	1.334	2.270	3.028	.120	.160
Pork	1.838	4.220	7.756	.550	1.011
Poultry	.686	2.700	1.852	1.050	.720
Mutton	.267	.250	.067		
Other	.375	.250	.094		
Other					
Milk	20.778	.210	4.363	.025	.519
Eggs	1.016	3.100	3.150	.600	.610
Total	(4.500)	(4.513)	20.310	(.671)	3.020
EC-9:					
Meat	17.500	(2.424)	42.413	(.472)	8.255
Milk	92.226	(0.148)	13.651	(.032)	2.948
Eggs	3.508	(3.100)	10.875	(.678)	2.379
Grain:					
Estimated			[4]66.939		[4]13.582
Actual			[5]66.911		[5]13.574

[1] Foreign Agricultural Service (FAS) supply and distribution figures supplemented by data from Food and Agriculture Organization (FAO) and the Organization for Economic Cooperation and Development (OECD). [2] Kg feed per kg livestock product. Use rates are obtained by budgeting with *a priori* knowledge from (*17, 19,* p. 6; *14*, pp. 118-119; *3; 31; 30; 8; 9; 11*). [3] Detail is the multiplication of livestock product detail by use rates. [4] Sum of above detail. [5] Reported by FAS.

Note: Italicized numbers in parentheses refer to items in References at the end of this article.

making decisions about how available crops will be shared by the family, the market, or animals in the form of feed. Although the practices of American agriculture are best known and documented, they stand at an extreme of behavior compared with world affluence (per capita income). Other developed countries typically use smaller quantities of grain in feeding livestock. Documentation by region, however, is difficult because of appreciable variation in local agricultural practice and infrequent or inadequate publication of data. Building the World GOL Model included obtaining and sometimes estimating this information.

As countries form a progression when classified by per capita income, so also they form a progression when classified by quantity consumed of meat per capita or proportion of grain allocated to livestock production (tables 3 and 4). Grain allocated to human food and to feed at the expense of food also tends to conform to the sequence. Thus one can judge the intensity of grain and oilmeal feeding, in regions with poor data, by looking at consumption and income. This consumption progression is referred to here as the Main Sequence. Variation observed in the feeding rates of the parts of the European Community and the United States is predictable from the Main Sequence (see figure 1 and table 3).

The United States, Canada, Japan, and parts of Western Europe possess grain-intensive beef industries, and in Europe, this industry is on the increase. Elsewhere, the grain-intensive meat industries are pork and poultry production. In much of the world, beef production is considered to be a byproduct of the dairy industry. Analysts cannot avoid arbitrary judgments in allocating feed to poultrymeat as against eggs, and to beef versus milk. And in important regions, allocation of feed must

Table 3—Per capita income and estimated meat and grain consumption, world, 1962

Income per capita	Meat	Grain for food and feed			Income elasticity		Grain-meat ratio[1]	Feed grain share[2]	Income per capita
		Food	Feed	Both	Meat	Grain			
Dollar equivalent	*Kilograms*				*Rate*			*Percent*	*Dollar equivalent*
25	0	48.8	0	48.8	∞	.84	0	0	25
50	0	117.8	0	117.8	∞	.32	0	0	50
75	5.2	144.3	4.0	148.3	3.41	.15	.7	0	75
100	9.8	156.5	13.0	169.5	1.50	.07	1.3	2	100
125	12.9	164.3	22.0	186.3	1.02	.01	1.7	5	125
150	15.2	159.4	30.0	189.4	.82	−.02	1.9	8	150
200	18.7	154.9	44.0	198.9	.65	−.06	2.3	12	200
250	21.4	148.9	53.0	201.9	.58	−.09	2.5	15	250
300	23.8	142.8	63.0	205.8	.56	−.11	2.6	17	300
350	25.9	137.3	71.0	208.3	.55	−.12	2.7	19	350
400	27.9	132.1	79.0	211.1	.56	−.13	2.9	20	400
450	29.8	127.5	86.0	213.5	.57	−.14	2.9	22	450
500	31.6	123.3	102.0	225.3	.63	−.14	3.2	24	500
750	40.3	107.2	138.0	245.2	.63	−.16	3.4	30	750
1,000	48.6	96.2	173.0	269.2	.68	−.17	3.6	36	1,000
2,000	80.9	75.9	320.0	395.9	.79	−.18	4.0	57	2,000
3,000	112.8	61.4	484.0	545.4	.85	−.18	4.3	77	3,000

[1] Kg grain per kg meat. [2] Feed in total grain consumption. Note: ∞ = infinity. Italicized numbers in parentheses refer to items in References at the end of this article.

Sources: Main Sequence equations—(*18*, Ch. 2; *19*, pp. 81-118).

Table 4—Demand elasticities, world

Commodity	Price elasticity		Income elasticity
	Meat	Grain	
Meat	−.60	.60	.60
Grain	.43	−.43	−.14

Sources: Main Sequence equations evaluated at the means; (*18, 19*).

Note: Italicized numbers in parentheses refer to items in Bibliography at the end of this article.

be made among beef, milk, and work. For oxen continue to be important as work animals, and sometimes milk cows are used for work.

OECD member country response to questionnaires on intensity of feed utilization (*14*) has helped scale the GOL input-output coefficients. Feed utilization rates tabulated for 1962, 1975, and 1985 are in basic harmony with the data underlying figure 1. They helped calibrate coefficients for the developed regions, Oceania, and (by inference) Argentina.

PRICE-ELASTICITY MATRIX

Price adjustment terms enter the feed demand equations which are based on estimates of direct- and cross-price elasticities for livestock products and for feed inputs. Research in ESCS has shown that feed demand equations conform well to the data when estimated from price series which are ratios of product prices to feed input prices (table 5).

Such relations, however, are nonlinear in numerators and denominators. Since the World GOL Model requires linearity among endogenous variables, elasticities of equal absolute value were assigned to numerator and denominator, but with sign changed in the denominator. Positive elasticities on meat prices, say, imply that an increase in a meat price brings an increase in feed use. Negative price elasticities on feed price, correspondingly, imply that a rise in a feed price brings a drop in livestock feeding. World cross-section calculations suggest that price response in demand may be the same, or proportional, over the world (table 4).

Table 5—Demand for livestock feed, EC-6

Feed use	Price ratios				Production constant		R^2
	PMG	PMO	POG	PGO	XM	K	DW
Grain							
FG	.491 (.266) E .51				1.123 (.095) E 1.26	-62.945	.97 1.27
FG	.521 (.129) E .55		-.128 (.054) E -.14		.881 (.108) E .91	-31.671	.99 2.13
Oilmeal:							
FO		1.144 (.530) E .97		-1.430 (.506) E -1.15	3.134 (.417) E 2.77	-183.377	.98 2.23

FG is feed consumption of grain, index of physical tonnage, 1960 = 100.
FO is feed consumption of oilmeal, index of physical tonnage, 1960 = 100.
PMG is the ratio of the price of meat to the price of grain, index 1960 = 100.
PMO is the ratio of the price of meat to the price of oilmeal, index 1960 = 100.
POG is the ratio of the price of oilmeal to the price of grain, index 1960 = 100.
PGO is the ratio of the price of grain to the price of oilmeal, index 1960=100.
XM is domestic production of meat and livestock, index of physical tonnage, 1960 = 100.
E is an elasticity evaluated at the means.
Standard errors are reported in parentheses.
Sources: (*18, 32*). Compare these results with those for the United States in (*1*).

WORLD CONSUMPTION OF GRAIN AND MEAT

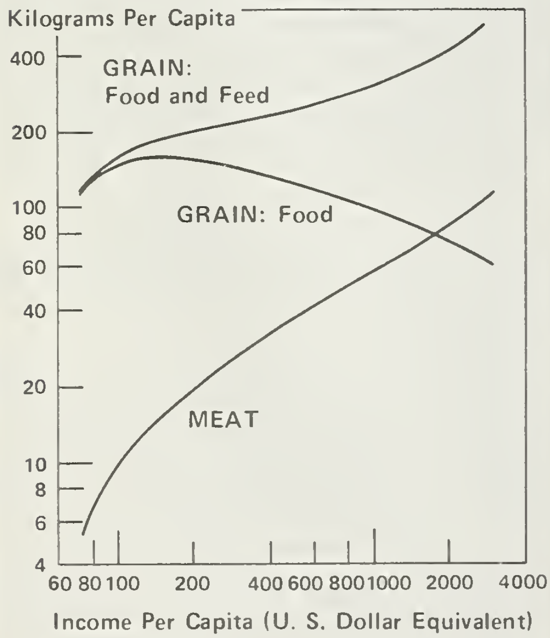


FIGURE 1

FEED DEMAND EQUATIONS

The elements discussed above are incorporated into the feed demand equations in this section. The feed demand equations in the World GOL Model for the EC-6 appear in table 6. The input-output rates in the equations can be traced from the rates in table 2. These relate domestic production of livestock products to total grain fed. The price coefficients represent elasticities of +.50 for pork, −.50 for corn, and +.10 for oilseed cake. In each equation a growth term is applied to the entire quantity of feed grain budgeted for livestock in the 1970 base period. The EC-6 growth term is 5 per mil (5 tenths of 1 percent) per annum, representing the European trend toward more grain-intensive livestock feeding practices.

Table 6 also shows the demand for feed wheat in the EC-6 as a linear function of total demand for feed grain and of the prices of wheat and corn. The proportion of wheat in total feed grain tends to rise with higher corn prices or lower wheat prices. Corn demand is a residual calculated by subtracting feed wheat from total feed grain.

Coarse grain demand in Brazil is shown (table 7) because it illustrates the GOL method for estimating feed demand in regions with deficient livestock feeding data or with rudimentary livestock sectors. Two input-output terms are shown, and price coefficients implying elasticities of +.30 for pork, −.40 for corn, and +.10 for oilseed

cake. For demand for livestock products not represented by beef and pork (the explicit terms in the equation), an income elasticity of .20 is stipulated. This elasticity, together with income- and population-growth terms shown in the table, determines the overall growth of this component of livestock feed demand.

Demand for oilmeal is illustrated from the EC-3 (table 8). Input-output coefficients are traceable to table 2. Price elasticities incorporated into equation coefficients are +1.80 for pork, +1.00 for corn, and −.37 for the direct price of oilseed cake. In structure the feed grain and oilmeal equations are similar, but the meal elasticities are greater. The 5 per mil growth term is comparable with the projected EC-6 growth term in grain feeding.

The growth terms used in these feed equations represent judgments concerning the future based on knowledge of economic development plans and projects under way around the world and a record of accomplishment or failure in the past.

Table 6—Demand for feed grain, EC-6, World GOL Model

Demand for feed grain			
• Total grain fed to livestock (1,000 mt)			Domestic production (1,000 mt):
	=	+	1.3000 Beef and veal
		+	3.6000 Pork
		+	2.7000 Poultry
		+	.2500 Mutton and lamb
		+	.1248 Milk
		+	3.1000 Eggs
			Price (Units of Account/t):
		+	30.9200 Pork
		−	304.4099 Corn
		+	45.7200 Oilseed cake
			Growth term
		+	46625.0000 (1.0 + .005) $^{\text{Time}}$
		−	46465.8000 Constant
• Wheat fed to livestock (1,000 mt)			Total grain fed to livestock (1,000 mt)
	=	+	.1850
			Price (Units of Account/t):
		−	20.0000 Wheat: Demand price
		−	50.0000 Wheat: Trade price
		+	50.0000 Corn: Trade price
• Coarse grain fed to livestock (1,000 mt)			Total grain fed to livestock (1,000 mt)
	=	+	1.0000
			Wheat fed to livestock (1,000) mt)
		−	1.0000

Table 7—Demand for feed grain, Brazil, World GOL Model

Demand for feed grain			
• Coarse grain fed to livestock (1,000 mt)			Domestic production (1,000 mt):
	=	+	1.5000 Beef and veal
			3.6000 Pork
			Price (Dollar equivalent/t):
		+	4.9440 Pork
		-	84.3100 Corn
		+	12.9900 Oilseed cake
			Growth term
		+	5928.0000 (1.0 + B)$^{\text{Time}}$ where:
			B = $a(b) + c$ = .04028 and
			a = .2000 income elasticity
			b = .0589 income growth rate
			c = .0285 population growth
		+	.5000 Constant

Table 8—Demand for oilseed meal, EC-3, World GOL Model

Demand for oilseed meal			
• Oilseed meal fed to livestock (1,000 mt)			Domestic production (1,000 mt):
	=	+	.1200 Beef and veal
		+	.5500 Pork
		+	1.0500 Poultry
		+	.0250 Milk
		+	.6000 Eggs
			Price (Units of Account/t):
		+	6.7300 Pork
		+	110.4500 Corn
			10.5300 Oilseed cake
			Growth term
		+	3028.0000 (1.0 + .005)$^{\text{Time}}$
		-	14273.0000 Constant

CONCLUSIONS

From one projection run on the computer to another, demand categories of grain for food and feed, oilmeal, and of meat production tend to move together. However, feed demand tends to respond with more sensitivity than food grain demand to variation in the assumptions underlying the alternative projections. In the various projections developed, quantities for meat production and consumption and grain for food have differed in a range of approximately 10 percent, whereas feed grain demand has varied through about 20 percent. The feed

grain variation occurs in the regions comprising the commercial meat economy of the world, thus, largely in the developed countries.

The variation among projections, in million metric tons, is shown in figure 2. Meat varied by 9 million tons, feed grain by 87 million, food grain by 53, and oilmeal by 9 million tons, with the meat, meal, and feed grain variation occurring largely in the developed countries. The 1985 projection levels (table 9)[3] ranged from 918 to 1,056 million tons for grain, 66 to 73 million tons for oilmeal, and 96 to 105 million tons for meat. The grain-to-meat conversion rate was 3.8 in the low projection and 4.3 in the high.

If the World GOL Model has been realistically designed, these results imply that the world livestock sector does act as a large secondary grain reserve. It is mainly a phenomenon of the developed countries and appears to help stabilize the world grain economy. Grain consumption as food appears strikingly stable in the developed countries while varying substantially in the less developed countries—but less than the variation in feed grain consumption. When world grain production is low, grain feeding apparently declines in the developed countries, mainly the United States and Europe. High world grain production tends to result in lowered feed prices which encourage larger developed country output of feed-intensive livestock products.

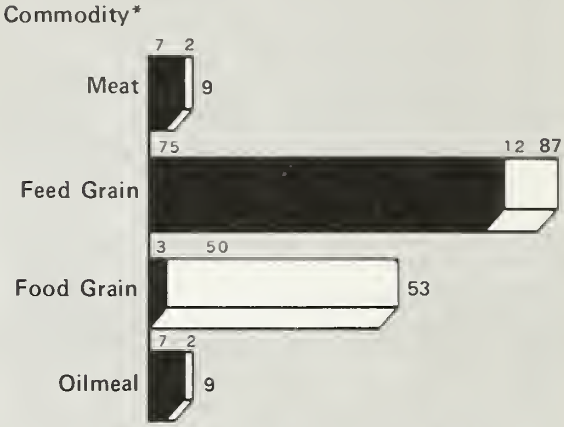
Additionally, the 1985 projections with the World GPL Model show that:

- High volume markets are for food grain in the developing countries and for feed grain in the developed countries;
- Developed country market for feed grain is large and growing;
- Developing country market for feed grain, though modest in scale, is growing faster than that in developed countries;
- Highest growth markets are for food and feed grain in the developing countries.

[3] For a more elaborate treatment of the projection results obtained with the World GOL Model, consult sources cited in footnote 2.

WORLD GOL MODEL: PROJECTION VARIATION AMONG ALTERNATIVES FOR 1985

Figures in Million Metric Tons



*Production of meat; consumption of grain and meal.

Developed Countries

Less Developed Countries

FIGURE 2

Table 9—Extremes of projections to 1985, World GOL Model

Projection alternative	Grain consumption			Oilmeal consumption	Meat production	Input-output rates	
	Total	Food	Feed			Grain	Meal
	Million tons					*Rate*	
Low	918	551	367	66	96	3.8	.69
DC	453	134	319	55	63	5.1	.87
LD	465	417	48	11	32	1.5	.34
High	1,056	601	454	73	105	4.3	.70
DC	529	135	394	62	70	5.6	.89
LD	526	466	60	11	35	1.7	.31

Notes: DC is Developed Countries; LD is Less Developed Countries; "Low" and "High" are world totals for tonnages or world averages for input-output rates. Italicized numbers in parentheses refer to items in Bibliography at the end of this article.

Sources: Summarized from (*25*) and (*18*).

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In Earlier Issues

Sir Horace Plunkett was an Irish institution, with broad English and American exposures. He was Irish by birth and deepest loyalty; part English by ancestral background and political participation; part American by lifelong business interests here. A core activity of his revolved around the establishment and expansion of agricultural cooperatives. He ranks with Grudtvig of Denmark and Raiffeisen of Germany as a pioneer in this field. He was anxious that a correct relationship exist between private enterprise and the government; that voluntary and statutory action be kept in constructive balance; and that self-help and state-aid be truly complementary. He hit upon the slogan "Better farming, Better business, Better living." President Theodore Roosevelt became tremendously interested in his three "betters," and presently announced them to rural America.

Arthur F. Raper
Vol. II, No. 2, April 1950, p. 71.

GAMBLING, INSURING, AND THE PRODUCTION FUNCTION

By Clark Edwards*

▲ A nonlinear production function can cause gambling or insuring in a risk situation. This result holds independently of the shape of the utility function for income. When a random variable enters an entrepreneur's production function with diminishing returns, profit maximization behavior can be likened to insuring. When the random variable enters with increasing returns, the behavior can be likened to gambling. Gambling and insuring do not necessarily depend on preferences and values; they may reflect rational adaptations to different environments.

▲ Keywords: Risk, diminishing returns, utility, optimization.

Gambling and insuring have been seen as rational utility-maximizing adjustments to risk when the decisionmaker's utility function is not linear with respect to income. If marginal utility increases for income above the current level, gambling is rational. Conversely, if marginal utility decreases for income added from a lower level to the current level, insuring is rational. Friedman and Savage state that this pattern of preferences could explain simultaneous gambling and insuring behavior by a single individual.[1]

The Friedman-Savage hypothesis justifies our use of the terms "gambling" and "insuring" to describe the rational behavior of an individual seeking to maximize expected utility when the utility function is nonlinear with respect to a random variable. We tend to use the same terms to describe the rational behavior of an individual seeking to maximize expected profits when the production function is nonlinear with respect to a random variable. The terms may be somewhat misleading in each situation because they carry connotations beyond what is really under discussion: the optimizing principles to use when determining whether to expose one's self to—or protect one's self from—risk.

INSURING AND DIMINISHING RETURNS

Consider an entrepreneur whose utility function is linear with respect to income. Maximum expected utility then corresponds to maximum expected profit. Profit (π) is defined as:

$$\pi = P_y Y - P_x X \tag{1}$$

where revenue depends on the sale of a product (Y) at price (P_y) and cost depends on purchase of a variable factor (X) at factor price (P_x). Let the entrepreneur be a price taker; that is, let P_y and P_x be predetermined.

Output (Y) is a function of the variable factor (X) controlled by the entrepreneur, and of a random variable (Z) over which the entrepreneur has no control, but which he can observe, and for which he can determine the probability distribution. The production function is:

$$Y = f(X, Z) \tag{2}$$

There are fixed factors not explicit in equations (1) and (2), which result in certain fixed costs that need not be examined. They will cause the production function to display diminishing returns to additions of the variable factor (X).

To illustrate the insuring behavior of the profit maximizing entrepreneur, assume that the random variable Z exhibits diminishing returns.

To make these ideas more concrete—we might think of Y as wheat; X as variable seed, fertilizer, and machine operating costs, applied in fixed proportions per acre; and Z as rainfall. In some regions, spring rains (from March to May) have a considerable effect on wheat yields. In some such areas, the average rainfall is just about right, and in some it is too little. In other areas, the average rainfall is too much, and there an additional increment of the input rain will decrease yields. For this illustration, assume a region where there is a range of diminishing returns to rainfall on wheat.

In the illustration, consider the Cobb-Douglas production function:

$$Y = 4.4721\ X^{0.75}\ Z^{0.50} \tag{3}$$

where Z is controlled by a probability distribution. The rainfall distribution may in reality be skewed. But to single out the effect of diminishing returns on insuring behavior, let us assume the distribution is symmetrical. A further, convenient simplification can offset some of the difficulties encountered in the calculus of expectations. Let us assume that Z has a rectangular distribution on the unit interval. This is a symmetrical function which is easy to integrate. The units of weather are no longer inches of rainfall, but random numbers between zero and one. The probability distribution for weather is:

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[1] Milton Friedman and L. J. Savage. *The Utility Analysis of Choices Involving Risk. J. of Pol. Econ.*, April 1948, pp. 279-304.

$$g(Z) = 1 \qquad 0 \leqslant Z \leqslant 1 \tag{4}$$

When equation (4) is substituted into the usual formula for calculating expected values, we have:

$$E(Z) = \int_0^1 Z\,dZ = 0.50 \tag{5}$$

which says the expected value of the weather variable is 0.50. The marginal physical product of X is

$$\frac{dY}{dX} = (0.75)\,(4.4721)\,(X^{-0.25})\,(Z^{0.50}) \tag{6}$$

Suppose that $P_y = 4$ and $P_x = 3$. Then the price ratio used as a choice indicator is:

$$\frac{P_x}{P_y} = \frac{3}{4} = 0.75 \tag{7}$$

If the entrepreneur assumes average weather (Z = 0.50) and solves equations (6) and (7) for the profit maximizing value of X, X equals 100. (The coefficient 4.4721 in this illustration was chosen so that X would be a convenient round number.) In this case, equation (6) is represented by line MP_o in the figure. Should there happen to be average weather (Z = 0.50), the yield (equation 3) will be 100, and profit (equation 1) will be $100 per acre. This result appears in table 1 in the section in which the entrepreneur assumes average weather and gets it. See also point A in the figure.

But, of course, weather is unlikely to be average in any year. Half the time, the random variable Z will be greater than 0.50 and half the time, less. Since there are diminishing returns, the added yields in years of good weather will fail to offset the lower yields in years of poor weather, and the expected yields will be less than that observed when average weather is experienced. This is shown by the shift to the left of the marginal physical product to MP_d in the figure. In the section of table 1 in which the entrepreneur expects and plans for average weather but the weather varies at random, the entrepreneur sets X equal to 100. However, the expected value of Y falls to 94.28, and expected profits fall to $77.14 per acre (point B in the figure).

This entrepreneur will soon learn to take a cautious view of the weather and to expect yields to average below what would be realized with average weather. Plans to reach A will, generally, be frustrated; with hindsight B is seen to be more realistic. The profit maximizing response will be to reduce outlays for (X) in accordance with these apparently pessimistic expectations.

The reason that realized situation B differs from the hoped-for situation A may be seen by comparing equations (8) and (9). The expected value of Z is 0.50, and Z enters the production function with an exponent of 0.50. When expected weather is assumed, yield is calculated using:

$$[E(Z)]^{0.50} = (0.50)^{0.50} = 0.7071 \tag{8}$$

but the expected value of $Z^{0.50}$ is smaller:

$$E(Z^{0.50}) = \int_0^1 Z^{0.50}\,dZ = 0.6667 \tag{9}$$

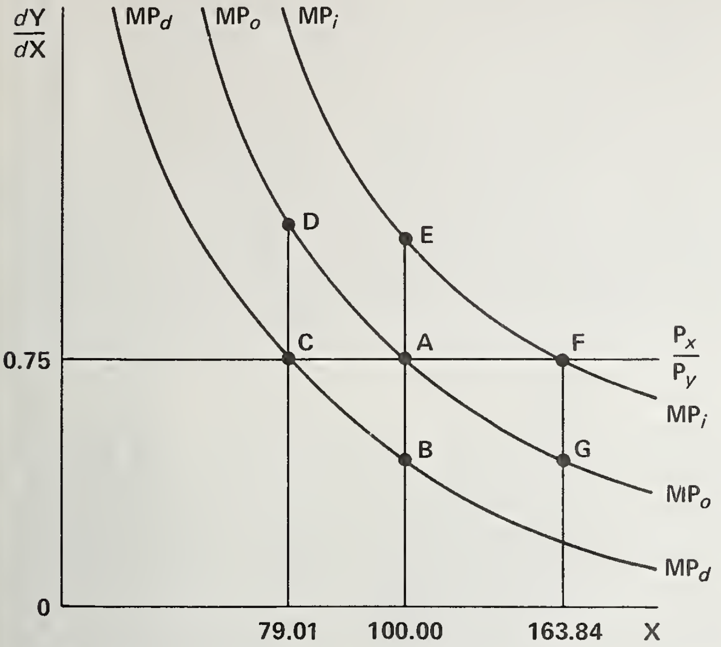
Introducing the expectation from equation (9) for the random effects of weather into the calculation of marginal physical product, equation (6), shifts the demand for X to the left (curve MP_d in the figure). When the entrepreneur sets expected marginal physical product equal to the price ratio, the level of X which maximizes expected profits is X equal to 79.01. The expected yield is 79.01 and the expected profit per acre is $79.01. This result is shown in the section of table 1 in which the entrepreneur expects and gets random weather over a series of years. See also point C in the figure.

Table 1—Insuring against diminishing returns: levels of input, output, and profit

Before	After					
	Realized average weather $[E(Z)^{0.50}] = 0.7071$			Realized random weather $E(Z^{0.50}) = 0.6667$		
	X	Y	π	X	Y	π
Expect and plan for average weather	100.00	100.00 A[1]	100.00	100.00	94.28 B	77.14
Expect and plan for random weather	79.01	83.81 D	98.18	79.01	79.01 C	79.01

[1] Points A, B, C, and D in the figure illustrate these four solutions.

OPTIMAL STRATEGIES UNDER DECREASING AND INCREASING RETURNS TO A RANDOM VARIABLE



Notes: MP_o is the marginal physical product of Y with respect to X, given that random variable Z assumes its expected value. MP_o is equation 6 for the diminishing returns case, and also is equation 11 for the increasing returns case. The high profit point if this curve occurs is A. MP_d is the expected marginal physical product when there are diminishing returns to random variable Z (equation 6); the high expected profit point is C. MP_i is the expected marginal physical product when there are increasing returns to random variable Z (equation 11); the high expected profit point is F.

The profit maximizing entrepreneur will make larger expected profits when a random variable enters the production function with diminishing returns if actions are conservative, and the uncertain outcome is discounted, than if average conditions are assumed.

An observer of the profit maximizing entrepreneur might interpret the behavior as informal insurance against bad weather. The entrepreneur discounts the weather and acts as if the weather variable Z were anticipated to equal only 0.4444 instead of its expected value of 0.50. Equation (9) shows that the expected value of $Z^{0.50}$ equals 0.6667, and it happens that $0.4444^{0.50}$ equals 0.6667. The curve MP_d in the figure corresponds to the curve that would obtain if Z = 0.4444 for certain.

As a rule of thumb, the rational entrepreneur may behave as if the weather each season would be such that Z = 0.4444. Average profit over time will be maximized even though the weather is higher than 0.4444 more often than not. This careful behavior can be likened to informal insurance against risk.

GAMBLING AND INCREASING RETURNS

Some weather variables display increasing returns through the production function. For example, corn grows well in hot weather. Along the northern edge of the corn belt, the expected temperature is cooler than farther south. The beneficial effect on yields of a hot summer in parts of this region can more than offset the reduced yield levels realized during a cooler summer.

Let us now assume that there are increasing returns to an uncontrolled weather variable (Z) but continue to assume that diminishing returns are experienced for addition of the controlled factor (X) to some crop (Y):

$$Y = 8.9443\ X^{0.75}\ Z^{1.50} \qquad (10)$$

where Z has a rectangular distribution on the unit interval as before (equation 4) and where the expected value of Z = 0.50 (equation 5). The marginal physical product of X is

$$\frac{dY}{dX} = (0.75)\ (8.9443)\ (X^{-0.25})\ (Z^{1.50}) \qquad (11)$$

and the price ratio remains as in equation (7).

If the entrepreneur assumes average weather (Z = 0.50) and solves equations (11) and (7) for the profit maximizing value of X, then X equals 100. Should average weather occur (Z = 0.50), the yield (equation 10) will be 100 and profits (equation 1) will be $100. This result appears in table 2 in the section in which the entrepreneur assumes average weather and gets it (see

Table 2—Gambling for increasing returns: levels of input, output, and profit

Before	After					
	Realized average weather $[E(Z)]^{1.50} = 0.3536$			Realized random weather $E(Z^{1.50}) = 0.4000$		
	X	Y	π	X	Y	π
Expect and plan for average weather	100.00	100.00 A[1]	100.00	100.00	113.14 E	152.55
Expect and plan for random weather	163.84	144.82 G	87.74	163.84	163.84 F	163.84

[1] Points A, E, F, and G in the figure illustrate these four solutions.

point A in the figure). Note that equations 3 and 10 have been standardized so that X equals 100, Y equals 100, and (π) equals 100 when the entrepreneur expects and gets average weather (Z = 0.50). Thus, curve MP_O in the figure can be interpreted either as equation 6 or equation 11.

Because there are increasing returns, the added yields in years of good weather will more than offset the reduced yields in years of poor weather. Expected yields will therefore be greater than when average weather is experienced (Z = 0.50). This result is shown in the section of table 2 in which the entrepreneur expects and plans for average weather but experiences random weather. The entrepreneur sets X equal to 100; the expected value of Y is 113.14, and expected profits rise to $152.55 per acre. See point E in the figure.

This entrepreneur will soon learn to take a chance on a good year and to assume the yields will average above what would be realized with average weather. The profit maximizing response will be to increase outlays for factor (X) in accordance with apparently optimistic expectations.

The reason that realized situation E differs from situation A may be seen by comparing equations (12) and (13). The expected value of Z is 0.50 and Z enters the production function with an exponent of 1.50. When there is average weather, yield is calculated using

$$[E(Z)]^{1.50} = (0.50)^{1.50} = 0.3536 \qquad (12)$$

but the expected value of $Z^{1.50}$ is larger:

$$E(Z^{1.50}) = \int_0^1 Z^{1.50}\, dZ = 0.4000 \qquad (13)$$

Introducing the expectation for the random effects of weather into the calculation of marginal physical product (equation 11) shifts the demand for X to the right as shown by curve MP_i in the figure. When the entrepreneur sets expected marginal physical product equal to the price ratio, the level of X which maximizes expected profits is X equals 163.84. The expected yield is 163.84 and the expected profit per acre is $163.84. This result appears in the section of table 2 in which the entrepreneur expects and gets random weather over a series of years. See point F in the figure.

The profit maximizing entrepreneur will make larger expected profits when a random variable enters the production function with increasing returns if actions are progressive rather than if actions are suited to average conditions. An observer might interpret the behavior as informal gambling for good weather. The entrepreneur marks up the weather variable and acts as if Z were anticipated to equal 0.5429 instead of its expected value of 0.50. Equation (13) shows that the expected value of $Z^{1.50}$ equal 0.4000, and it happens that $0.5429^{1.50}$ equals 0.4000. The curve MP_i in the figure corresponds to the curve that would obtain if Z = 0.5429 for certain.

As a rule of thumb, the entrepreneur may behave as if the weather each season would be such that Z = 0.5429. Average profits over time will be maximized even though the weather is poorer than 0.5429 more often than not. This positive behavior can be likened to informal gambling under risk.

CONCLUSION

Economic behavior which is variously characterized as gambling or insuring, optimistic or pessimistic, liberal or conservative, is often explained by reference to values and preference patterns. However, such behavior may instead be a rational adaptation to the physical environment. Behavior which we tend to characterize as insuring, pessimistic, and conservative may express a rational adaptation to a random variable which is experienced under conditions of diminishing returns. Gambling, optimistic, liberal behavior may express a rational adaptation to a random variable which is experienced under conditions of increasing returns.

FOOD POLICY FOR AMERICA

Halcrow, Harold G., New York, McGraw-Hill Book Company, 1977. 564 pp. $19.50.

*Reviewed by Lowell S. Hardin**

The U.S. Department of Agriculture, according to one of its policymakers, is no longer a department of agriculture. Rather, it is a department of food, agriculture, and rural development and resources. With this assertion Harold Halcrow would surely agree. For, as reflected in its title, his book emphasizes food as a subject broader than agriculture, and he reinforces the point by including a final chapter on nutrition policy.

This wide-ranging, often descriptive book effectively argues that, in today's interdependent world, national food policy goals can no longer be achieved in a narrow sphere. Concerns about energy, a food reserve, exports, environmental protection, equity, income distribution, nutrition, and general welfare merit simultaneous consideration—if not equal billing—on the extensive food policy agenda.

The author brings us to this comprehensive view by reviewing the evolution of U.S. food policy through three eras. Era I—from Jamestown to 1920—was characterized by policies to encourage land settlement during our national encounter with the frontier. Throughout this 300-year period, our land-based growth model of settlement, development of transportation, and markets was pursued with policies thought to be generally favorable to the family farm.

Policy Era II—1920's to early 1970's—was based on science and technology. Fundamental to this cost-reducing, output-increasing "green revolution" in U.S. agriculture were public policies and programs: (1) based on research and education; (2) designed to assure a flow of capital into agriculture; (3) striving for greater standardization of Federal-State rules and regulations; and (4) generally lenient in their support of public developmental services. Within this 50-year period, our own scientific revolution spawned spectacular advances in farm machinery, crop improvement, and the use of chemicals, all of which yielded unprecedented increases in output per worker.

In the early 1970's we entered food policy era III which is characterized by a new international interdependency. Major changes in the world markets have shifted requirements more heavily toward the late-developing countries. Simultaneously problems of energy availability and prices and widespread concern for the quality of the environment have become critically important. Now food policy must

> help stabilize markets against the types of violent fluctuations that have occurred without being restrictive in regard to production and trade. A new policy in regard to food reserves must emerge, based on a new consensus between producers and consumers and involving an important new element of rural-urban understanding and cooperation (p. 84).

Having set out to link U.S. food policy to the welfare of people at home as well as abroad, the author stresses the importance of setting food production goals (chapter two). Here both short and longer run U.S. and world population and food production potentials are analyzed. The tone is one of cautious optimism, not of impending catastrophe. Understandably, export market management is seen as critically important to the future welfare of the United States.

How policies relating to trade, exchange rates, aid, and income subsidies influence the demand for food is treated in chapter three. Here we are taken through the fundamentals of elasticities, market structure, and our varied experiences with supply-management programs.

Having established the probable need for greater food supplies, the author (chapter four) considers production potentials and how policies influence the way we develop and use our resources, especially land and water. We are introduced to the determinants of the size of farm, become acquainted with the economic structure of the farm machinery and equipment industry, and are updated on the use of fossil energy, and the economics of fertilizer and pesticide application. Here we are shown why taxation, credit, and development policies tend to favor larger farms, to concentrate production in fewer hands. However, Halcrow concludes that "increases in supply will tend to become more slowly as the transitional growth in input industries tends to stabilize" (p. 137).

Chapter five introduces us to the politics of national policymaking, the roles of interest groups, and the historical roots of current food policies and programs. Important recent transitions in food policies are seen as

> not generally led by the power of the federal government or even encouraged by it. They came largely from movements and groups outside of government—especially an awakening knowledge about hunger among the poor (p. 187).

Generally government is given low marks in the areas of consumer protection, and pricing and competitive practices within the food industry. Chapter six acquaints us with the important farm organizations, their effectiveness (or lack of it) in exerting influence on the national scene. Halcrow sketches for us the development of farm organizations, tracing their origins to farm and agrarian discontent concerning low incomes and limited educational and alternative employment opportunities.

The last half of the book presents more specifically some alternatives in product pricing, management, and trade (chapter seven); and markets for agricultural land, capital and credit, human resources and incomes (chapters

*The reviewer is a program officer with the International Division, Ford Foundation.

eight, nine, and ten). The book concludes with a chapter on our unresolved nutrition problems and ways to integrate food and nutritional concerns with each other. Here again, heavy emphasis is placed on the need for more research into the nature of poverty-malnutrition linkages and increased nutritional education for all—especially the lower income groups.

To whom is the book addressed? To all of us who are interested in public policy, including students of the world situation and the U.S. role in furthering food security and development. At once, the book is a comprehensive introduction, a text, a reference, and a well-documented guide to more study. Policy goals, means, and the author's generalized conclusions are set forth in a straightforward and understandable manner.

Few blueprints or results of original research on emerging issues are offered. These are not the book's objectives. It describes, analyzes, criticizes, and, while it seldom prescribes specific detailed solutions, it sensitizes. Because of the breadth of coverage, the book gives us little more than an introduction to such important topics as nutrition policy or possibilities for widespread improvement in the quality of life for the less advantaged. Primary emphasis is on policies designed to obtain a secure, safe food supply at acceptable prices—with progress, prosperity, efficiency, and equity. A tall order, yes. However, to this reviewer, the book accomplishes much of what the author set out to do—to help launch all of us into an expanded food policy agenda that now, of necessity, requires a global perspective.

SEMINARS ON FOOD POLICY *

*By William T. Boehm and Thomas A. Stucker***

Human nutrition and food policy analysis have been designated as areas of increasing priority in the U.S. Department of Agriculture and its Economics, Statistics, and Cooperatives Service (ESCS). Pressures for an integrated domestic food policy continue to build. Increasingly there will be requests for analytical support as these complex issues are debated in the policy arena.

To help provide needed information and perspective, ESCS sponsored a series of five national food policy seminars. The issue-oriented papers presented at these seminars will be published in a 1978 issue of *Agricultural-Food Policy Review.*

Objectives of the seminars are these:

- To identify, describe, and discuss the key food policy issues which will need to be resolved over the next 2 or 3 years.
- To assess current research evidence and to stimulate additional food policy research.
- To help define boundaries and establish priorities for an expanded food policy research program in ESCS.
- To acquaint the research and policy community with food programs research in ESCS.

Food Policy Seminar I: The Emerging Concern for Human Nutrition and World Hunger November 28, 1977

The first of the food policy seminars set the stage for the discussion of contemporary issues in food policy. Kenneth Farrell, Acting Administrator of ESCS and moderator of the first session, stated that development of a comprehensive national food policy would require meshing the food production and nutrition elements and consideration of marketing and regulatory policies. This policy would be linked with the international dimensions of food production, trade, and aid. The linkages among elements in a national food policy, such as food production, food consumption, and human nutrition are not well identified nor understood, said Farrell. This condition persists, despite large public investments in research, for several reasons—among them, lack of knowledge, segmented policies, and too narrow a focus. Drawing together the various segments of food policy to meet this challenge, added Farrell, implies the synthesis of USDA research. He emphasized the need for interdisciplinary coordination of knowledge about food and nutrition.

Howard Hjort, USDA's Director of Economics, Policy Analysis, and Budget, discussed the role and underlying motivation for food policy analysis in the Department. He emphasized the importance of recognizing that the "food system" *is* a system, and that analysts must trace impacts of shocks throughout the system. Our domestic food system is part of an international one, and the "openness" of the U.S. food system dictates that our food sector is subject to greater shocks than are some other national food systems. Our domestic food system is a major source of world food supplies. It is tied to world economic activities and worldwide variations in weather. The scope of food policy includes factors as diverse as farm prices and the U.S. balance of payments.

Hjort characterized broader participation in the policy process as a manifestation of the diversity and complexity of the food system components, and as an opportunity to open new lines of communication to better serve the public. The Congress reflects this expanded group of participants in the agricultural and food policymaking process. Adding to the complexity of the decision-making process is the importance of the judiciary in resolving conflicting socioeconomic questions. The policy agenda can be influenced, he stated, by conducting good research and communicating results in a way which brings significant economic issues to the public's attention.

Sol Chafkin of the Ford Foundation cautioned of the danger of addressing food programs rather than policies, and of the danger of too

*Editors' note: Reports on the remaining two seminars will appear in the July issue of this Journal.

**The reporters are agricultural economists with the National Economic Analysis Division, ESCS.

much research and talk without substance and action. These reflect the difficulty in approaching food policy because of its size and complexity. Chafkin described human nutrition as a "growth industry" with much current activity but noted that real and significant changes are difficult to achieve. The concept of malnutrition has changed, he said, and it is now recognized as a separate problem from hunger. We are dealing, worldwide, with an immensely large number of people suffering from mild malnutrition, both in the United States and abroad.

Food policy changes imply a basic reordering of priorities with respect to nutrition and welfare compared with other social objectives, added Chafkin. When dealing with an interdependent food system, several new policies have to be adopted at the same time to change one part of the system, a difficult task. In some senses, we have to focus on only a part of the system and decide on our primary concern. The real policy choices and decisions will be made when pain is felt on one side or the other of the consumer-cost/farm-income tradeoff.

Lynn Daft of the Domestic Policy Council said that food policy has become an important issue, yet our current programs and policies leave much to be desired. Responsibilities among Federal agencies, other institutions, and even among countries are as yet unclear. Daft said we are uncertain about the role of government and about the facts and reality of nutritional problems. Diverse viewpoints complicate the policy process.

He concluded that a food policy is beginning to unfold. The executive branch is now sorting out institutional roles and responsibilities. To be effective in handling and resolving conflict, the U.S. Department of Agriculture will need to broaden its interests and cover a broader range of concerns. Yet it also needs to maintain a distinction between the research process and the advocacy of policy.

Carol Foreman, USDA's Assistant Secretary for Food and Consumer Services, stated that the growing concern over human nutrition, one both domestic and international, is being strongly reflected in the changing attitudes of the Department. Both consumer and producer interests must be considered in a national food policy, Foreman said. The policy has several elements:

- A research program to determine people's nutritional needs and the production needed to meet them
- Consideration of international food needs
- Measures necessary to stimulate an adequate level of production at reasonable prices
- Assurance of a safe and high-quality supply of food
- Assistance programs for those who cannot afford adequate food at market prices
- Consideration of distribution as well as production.

The Department of Agriculture, Foreman stated, is an important part of any attempt at a cohesive food policy. The fact that the Secretary of Agriculture is required legally to protect the public interest in food safety and quality, and food assistance programs, she concluded, assures that the Secretary and the Department will not be forced into a narrow role.

Food Policy Seminar II: Public Assistance Programs and Food Purchasing December 14, 1977

Resource transfers through public assistance programs influence the quantity and distribution of food. These relationships served as the topic of the second food policy seminar, chaired by Lyle P. Schertz, ESCS Acting Deputy Administrator for Economics.

Richard Nathan of the Brookings Institution opened the second session from the point of view of a social welfare policy economist. Those who came expecting to hear Nathan defend continuation of the Food Stamp Program, based on its influence on food purchasing by low-income people, were disappointed. Nathan did not refer to its food purchasing implications or effectiveness. Instead, he argued for continuation of current welfare assistance programs, including the Food Stamp Program, because they largely satisfy stated political and social objectives.

Recalling his days as chairman of the President's Task Force on Public Welfare in 1969, Nathan stated that the proposed Family Assistance Plan (FAP) in 1969 had the following objectives:

- Assist the working poor
- Set minimum national benefit standards
- Aid the aged, blind, and physically disabled
- Help welfare family heads find and keep jobs through work incentives.

While the FAP was never adopted, Nathan argued that other legislation has been adopted since 1969 to accomplish all four objectives. The Food Stamp Program, he said, provides assistance to the working poor and helps reduce regional inequities in public assistance. The program "does important things in an acceptable way and helps millions of people. It helps people more during recession periods and that, to me, defines a good program in the income security field."

Nathan addressed his concept of "welfare incrementalism." "What we need is next steps—not total welfare reform." We should, he recommended, evaluate elimination of the food stamp purchase requirement as a next step instead of trying to put everything together in some grand scheme. "I don't think we should go the full way faster than we can digest change and faster than change is really understood," Nathan said.

The belief exists that welfare reform proposals today must start with a premise that no more money in total can be spent on public assistance, the speaker pointed out. Given that premise, it may be even more important, he believes, to have incremental changes from current programs, and to have targeted programs to accomplish specific legislative objectives.

Dr. Sylvia Lane, an agricultural economist from the University of California at Davis, focused on poverty, food selection, and nutrition. Food selection tends to be highly correlated with the income and educational levels of the shopper. Public resource assistance (coupons or cash) cannot be expected to *ensure* that participating households have adequate diets.

According to studies reviewed by Lane, approximately 70 percent of all U.S. households in 1976 had the resources needed to "afford" the foods implied by USDA's lowest cost food plan but only 21 percent could "afford" the "liberal" plan.

Because people make food substitutions, "not affording the plan does not necessarily mean that they (the households) were under or malnourished."

Lane said "the 'poor' could obtain a nutritionally adequate diet for less than they now spend on food, but the less they spend, the less palatable, the starchier, and the more monotonous the diet becomes." The poor, she said, are limited in their access to food because of low incomes and they are probably paying higher prices. Nonetheless, she concluded, they "appear to be relatively efficient in obtaining nutrients per dollar of food expenditure." People with high incomes often eat unbalanced diets, and obesity is an important nutritional problem for them.

Lane also reviewed studies which support a program for increased nutrition education and a targeted food program for which the policy objective is to improve the nutritional adequacy of low-income people who have smaller budgets, less nutritional knowledge, and are likely to pay higher prices.

The relationship between food programs and nutritional intake was reviewed by Benjamin Sexauer, agricultural economist from the University of Minnesota:

> Nutritional evaluations present a number of complicated, in some cases insolvable problems which cannot be overlooked. Our current understanding of dietary needs is incomplete, there are recommended daily allowances for only 17 of the more than 45 *known* essential nutrients.

In addition, "nutritional needs vary tremendously between individuals, not only because of sex, age, body size, and activity, but also due to genetic make-up and physiological state." Therefore, studies which attempt to assess the nutritional impact of USDA's food program will likely not be conclusive.

Sexauer's evidence tended to indicate some nutritional improvement due to Food Stamp Program participation, "but not a marked change." The reasons, he suggested, include: (a) coupon substitution for some of the cash income food stamp participant households had previously spent for food, and (b) continued purchase by these households of types of food they are familiar with "rather than items which would remove the nutritional deficiencies in their diets." However, Sexauer made the important point that, for many, the program has "eliminated the kind of chronic hunger among the poor that shocked the public in the late 1960's."

Studies on the nutritional consequences of USDA's other food programs reviewed by Sexauer also indicate some, but limited, improvement. Supporting Lane's conclusion, Sexauer said that "the existing studies seem to indicate that food programs should include a nutrition education component."

William T. Boehm and Paul E. Nelson, ESCS agricultural economists, reviewed the aggregate food expenditure consequences of the proposed Better Jobs and Income Program (BJIP), the Administration's proposal for comprehensive welfare reform. The research issue was how a simple cash transfer system, as is proposed in BJIP, might influence aggregate food expenditures relative to continuation of the present welfare system with a targeted food assistance program. They conclude that "aggregate food expenditures would be largely unaffected by implementation of BJIP." Their estimate is that with BJIP, food expenditures in total would fall $1 billion—less than one-half of 1 percent—if current programs were retained, and by only about $300 million with the food stamp purchase requirement eliminated.

The authors provided the following explanation of their estimates. The BJIP would increase the *total* grant to the poor by about $2.8 billion. "This increased level of funding helps to explain, in an important way, why food expenditures and farm incomes will, for practical purposes, not likely decline as a result of the proposed change." Aggregate expenditures are not expected to change significantly as a result of the BJIP. However, the authors stressed a cash transfer scheme is "simply not as effective in influencing the food purchasing behavior of recipient households as is a targeted program like the food stamp program."

Only about 50 percent of those eligible to receive food stamps actually participate in the program. A cash assistance scheme, said Boehm and Nelson, would likely affect more of the target population. A food stamp program is more effective in increasing the food buying of *participant* households. But variability of participation rates alone makes it difficult to indicate which type of program is likely to influence aggregate food purchases the most.

Food Policy Seminar III: The Equitable Distribution of Food Aid January 17, 1978

Equity of food distribution rather than efficiency of food programs was emphasized in the third food policy seminar. Bob Greenstein, Special Assistant to the Secretary of Agriculture, the moderator, said that most discussions of equity relate to concerns about equitable distribution *within* the eligible target group. But analysts should not forget that the food aid programs were designed to reduce the vertical inequities generated when some members of society do not have the resources to purchase nutritionally adequate diets. Greenstein cautioned that program rules must accomplish other than equity goals. They must be operationally sound and easily understood, and adjust to conflicts among different interest groups:

> When program funds are relatively fixed because of budget considerations, we may well opt for a set of program rules which sacrifice some horizontal equity in order to increase the proportion of total funds actually going to the target population.

Keynote speaker C. Peter Timmer, Professor of the Economics of Food and Agriculture at Harvard University, recalled that the tools of economic analysis are mostly suited to considering questions of efficiency. "But," he added, "when the familiar equity-efficiency tradeoffs become the real agenda item, economists feel a God-given right to have the last word."

Two fundamentally different approaches exist to the equity issue, Timmer said. The micro approach "would look carefully at each of the food aid programs, and determine the 'fairness' or 'equity' of the legis-

lative rules for each." The macro approach

> would look at the entire U.S. economy and ask how it *generates* the unequality... If manipulations of variables in these mechanisms do not provide a satisfactory distribution of material well-being then a sequence of more targeted programs can be brought to bear on the problem.

His remarks are based on the macro approach.

Focusing on the analytical setting for policy analysis, Timmer indicated that it was fundamental to understand the linkages among three variables: agriculture, food, and nutrition. Any of the three could serve as the planning focus; however, both agriculture and nutrition were too narrow a focus, he said. The political constituency of either is "too small for this [macro] approach to be implemented." The alternative is a "food sector perspective," which recognizes that food is the primary intermediary between agriculture and nutrition. Planning from this perspective has the advantage of a central focus on individual markets, still the most efficient mechanisms available for distributing commodities.

A food policy based on a broader perspective would be far enough removed from agriculture so as not to be dominated by producer interests. At the same time, nutrition would not be seen as the only element. Such a policy, Timmer indicated, also provides the proper orientation for equity questions in the context of analysis and planning.

Although no harm exists in starting on a piece of the problem, it is important "to understand where that piece fits in the broader scheme of things." Refering to past dairy policy for an example, Timmer said, "The issue is not milk prices, but the policy perspective that permits manipulation of prices on producers' behalf and relegates consumer interests to the program level." Such programs may transfer income from the higher income nonfarm sector to the lower income farm sector, as intended. But they may also result in income support to farmers who are wealthy relative to certain nonfarm poverty groups who face higher milk prices. "The obviousness of the unequal perspective in terms of historical evolution and political realities should not hide the fact that it produces bad policy analysis."

These remarks served as the basis for suggesting a research agenda which would contain five broad research questions, corresponding to five levels of equity issues:

- What are the linkages between the world food economy and the U.S. domestic food policy?
- What is the impact of U.S. agricultural price policy on income distribution, food consumption, and the nutritional status of the poor?
- Can minimum standards for food programs be defined that reconcile the major philosophical differences between participants' need for dignity and taxpayers' concern for program costs?
- What are the social, cultural, and health factors that prevent use of existing programs?
- How do the poor spend their money, and what factors cause the purchase of nutritionally inadequate diets?

The next three papers in the seminar contained reports on inequities which likely result from current program rules regarding the distribution of benefits. Thomas Stucker, Michael Belongia, and Robert Rizek looked at problems with the benchmarks: poverty and the Thrifty Food Plan. Larry Salathe and Rueben Buse examined the household as the consumption unit, and Thomas Carlin, regional versus national eligibility standards.

Differences in the costs of living and the rules allowing for various deductions from earned income were two of the major reasons given for generating inequitable distribution of aid under current programs. Carlin indicated that Federal jobs programs, in particular, pose a real problem for rural areas (where many of the unemployed poor now live) since public service jobs in such areas are limited.

The speakers presenting these three papers concluded that, while technical improvements in the equitable distribution of aid could undoubtedly be obtained by changing current program rules, such improvements could not logically be expected without substantial increases in administrative complexity and, thus, costs.

The final speaker, Maurice MacDonald, from the University of Wisconsin's Poverty Institute, discussed the factors affecting participation. He asked whether the Government had a responsibility to do more than just *offer* public assistance. Wasn't there also a responsibility to see to it that aid was *accepted* by all those in the target group? He has found that some in the target group do not receive the aid for which they are eligible because of the societal stigma attached to the acceptance of public assistance. He suggested that cash assistance would be less apt to be stigmatized than a targeted program using, for example, food stamps.

In Earlier Issues

The price indexes of the Bureau of Agricultural Economics are widely used not only for general purposes but also in the administrative calculation of parity prices which current legislation provides are to be so determined as to give farm commodities generally the same purchasing power in terms of "articles and services that farmers buy, wages paid hired farm labor, interest on farm indebtedness secured by farm real estate and taxes on farm real estate" as prevailed during the base period January 1910-December 1914. This means that the indexes must measure broad changes over something more than four decades. This requirement sets a most difficult task in constructing farm price indexes, especially the parity index covering prices and cost rates paid by farmers owing to the great shift in farm production methods and, equally, farm family living patterns since 1910.

O. V. Wells
Vol. II, No. 2, April 1950, p. 33.

AGRICULTURAL CENSUS DATA AS A SOURCE OF LINEAR PROGRAMMING VECTORS

*By Daniel G. Williams**

Agricultural production functions vary by region in the United States. To study agricultural production in alternative regions, analysts require regionally specific data for the functions. If these data are to be obtained from primary sources, it can be both expensive and time consuming. In this note, I describe a method for constructing the agricultural sector of a linear programming model which is used for planning economic development in a rural, multicounty area. The method may prove to have a wider use than for the agricultural sector, perhaps for the manufacturing sector as well. The table gives a simplified representation of the agricultural subsector of the larger model.

Model

The prototype model was developed originally by the Stanford Research Institute (SRI) under contract to the U.S. Department of Agriculture.[1] The agricultural subsector of that model relied on primary local data. Work was initiated by SRI and completed by the present author at USDA to reformulate the agricultural subsector to use secondary data. The results of this reformulation are included in the current version of the model: Rural Development, Activity Analysis Planning (RDAAP), based upon a model foundation in which both size and scope of industry mix were expanded by SRI from the prototype version.

Three additional articles by this author explore other areas of the research.[2] Also, two manuscripts by the author summarize certain aspects of the entire model research. The first[3] is essentially a recapitulation of some of the more important research results, including a portion of the material from this note and from the other three papers mentioned. The second[4] presents the structure and mathematical framework of the model.

Agricultural Sector—Production Vectors

In SRI's development of the model, one problem involved the reconciliation of two conflicting objectives. The model was to be useful for many different areas of the country, yet also as specific as possible for any one area. In the manufacturing and service sectors, this conflict was resolved by "ruralizing" the vectors from the national input-output table.[5] For the agricultural sector, however, it was thought that the production functions would vary more between regions than for the manufacturing or service sectors. Thus, the methodology for constructing the agriculture sector had to be more area specific. Yet, SRI did not wish to require the gathering and use of separate primary agricultural data for each area to which the model was to be applied.

The usual methods for constructing agricultural production vectors did not seem appropriate. Generally, the agricultural sector of a model involves separate production vectors *for each individual output*, including, for example, distinct vectors for cash grain, farm animals, fruits and vegetables, and forage crops. This commodity-specific procedure is used by Spiegelman, *et al*, in the forerunner to the RDAAP Model. It was suggested to SRI[6] that both secondary agricultural data, and a noncommodity-specific agricultural format could be employed. Instead of focusing on separate products, one could focus on farm types to exploit regionally specific data available from the U.S. Census of Agriculture.[7]

However, the multicounty "regional" data, including State parts, do not exist in the most recent U.S. Agricultural Census. Since the 1954 Agricultural Census, no detailed data have been published for economic areas. But from the 1959, 1964 (used in this study), and 1969 censuses, ESCS obtained a special tabulation for multicounty areas (including State parts). Such tabulations can no longer be obtained at the detail used in the RDAAP Model. At the State level, however, approximately the same data detail is still provided in the published U.S. Agricultural Census documents. These data are not, of course, as "regionally" specific as before, but are more area specific than if national average production functions were used.

To implement this procedure using the 1964 data, I obtained a detailed computer printout from the census for Washington and Benton counties combined, rather than for the more aggregated geographical areas in the published volumes. The farms are classified by economic

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*The author is a regional economist with the Economic Development Division, ESCS.

[1] Robert G. Spiegelman, E. L. Baum, and L. E. Talbert. *Application of Activity Analysis to Regional Development Planning: A Case Study of Economic Planning in Rural South Central Kentucky*. U.S. Dept. Agr., Econ. Res. Serv., Tech. Bul. 1339, Mar. 1965.

[2] (a) *Objective Function Tradeoff Curves in a Rural Economic Development, Activity Analysis, Linear Programming Planning Model* (unpublished paper).

(b) *Use of Multiple Regression Analysis to Summarize and Interpret Linear Programming Solutions: Aplication to a Rural Economic Development Planning Model* (unpublished paper).

(c) *On the Problem of Attracting Industries Specified by the Solution to a Linear Programming, Rural Economic Development Model* (unpublished paper).

[3] *Planning for Multicounty Rural Areas: Application of a Linear Programming Economic Model in Northwest Arkansas* (unpublished manuscript).

[4] *Structural Details of a Linear Programming, Rural Economic Development Planning Model: Northwest Arkansas* (unpublished manuscript).

[5] SRI used the "base" data of the U.S. Department of Commerce 1958 input-output table (approximately 4-digit SIC), and used what would be, in essence, "5 or 6 digit" SIC data. These were separated into rural (non-SMSA) and urban (SMSA) components. The former was used to create the manufacturing and service vectors in the RDAAP Model (at approximately the 4-digit SIC level).

[6] By Clark Edwards, ESCS.

[7] For the RDAAP Model, applied to the BMW Region, consisting of Benton, Madison, and Washington counties in northwestern Arkansas, the *1964 U.S. Census of Agriculture*, Arkansas, Bureau of the Census, U.S. Department of Commerce (detailed computer printout for Washington and Benton counties combined) was used.

class, as well as type. The classes run from Class I (the highest-income farms) through VI, and part-time. Types of farms for the BW Region[8] are poultry, dairy, general livestock, fruit and nut, cash grain, and vegetable.

Agricultural Sector—Transformation Mechanism

The model "transforms" regressive farms (Classes IV through part-time) into progressive farms (Classes II and III). The jump from Class IV or below to Class I is thought to be too large to be realistically obtainable. If progressive sectors enter a model optimal solution, it implies that higher economic class farms embody more efficiency in their use of land and other resources than lower economic class farms, for the particular objective function and constraints assumed. Each farm type generally produces the entire full range of agricultural outputs.[9] Of course, cash grain farms produce relatively more wheat and other cash grains, vegetable farms produce relatively more vegetables, and so on. Columns 2 and 3 of the table illustrate two progressive types of farm: poultry and general. Each type of farm produces the full range of farm commodities; shown in the table are sorghum, barley, and hogs.

The progressive sector in the complete model includes 12 farm production vectors.[10] The regressive sector, for simplicity, is not disaggregated (as to type and/or class). Thus, the agricultural regressive sector consists of only one production vector (column 1 in the table).[11] The upper limit on the amount of land able to be converted for use by the progressive sector is the total amount of land in the regressive sector in the BMW Region.[12]

What is the exact mechanism of transformation from regressive to progressive agriculture? Crop outputs from the progressive sector are indicated by plus signs on the coefficients. Livestock outputs appear with minus signs in the progressive farm columns because these coefficients function as feed requirements. Hog

[8] Data from the computer printouts are given for only Benton and Washington counties combined, not for the whole BMW Region. This omission is satisfactory since the data are being used to create prototypes for the area-specific production vectors. And, it is assumed that these vectors will be sufficiently accurate, especially since Benton and Washington counties are both much larger agriculturally than Madison county.

[9] 29 different detailed (disaggregated) agricultural commodities are considered.

[10] 7 types times 2 classes = 14 different farm varieties. However, Economic Class II farms for 2 of the 7 types do not exist in the BW Region. Class II farm "units" are 15 individual farms; Class III farm "units," 25 individual farms.

[11] One farm "unit" is calculated to be 50 individual regressive farms.

[12] Land is classified into 5 types: total farmland, cropland harvested, cropland pasture, improved pasture, and unimproved pasture.

Simplified representation of the agricultural subsector in the RDAAP Model

Columns / Rows	Agriculture									Manufacturing		
	Production				Barley		Feed grain transfer	Grains and seed		Prepared animal feed		
	Regress	Poultry	General	Feed hogs	Imports	Exports		Transfer	Imports	Produce	Imports	Exports
Agriculture:												
Sorghum	$-a_1$	$+b_1$	$+c_1$	$-d_1$								
Barley	$-a_2$	$+b_2$	$+c_2$		+1.0	−1.0	$-g_1$	−1.0				
Hogs	(1)	$-b_3$	$-c_3$	+1.0								
Feed grain	[1] $+a_3$			$-d_2$			$+g_2$					
Grains and seeds								$+h_1$	+1.0	$-i_1$		
Manufacturing:												
Prepared animal feed	$+a_4$			$-d_3$						+1.0	+1.0	−1.0
Soybean oil	$+a_5$	$-b_4$	$-c_4$							$-i_2$		
Land:												
Cropland	$-a_6$	$+b_5$	$+c_5$									
Labor:												
Skilled	$-a_7$	$+b_6$	$+c_6$							$+i_3$		
"Foreign" sector:												
"Foreign exchange"	$+a_8$	$-b_7$	$-c_7$		$-e_1$	$+f_1$			−1.0	$-i_4$	−1.0	+1.0

[1] For technical reasons, the regressive sector livestock rows (which would be positive) are converted into their individual vector components, such as "feed grain commodity," at positive ("supply") levels.

production from all farms in the region is indicated by the +1 coefficient in the feed hogs column of the table. Except where indicated, all signs on the coefficients in the regressive sector are reversed from those of the progressive sector.

Before a net increment[13] of production of a particular agricultural commodity can be produced, the "loss" of the regressive sector has to be "made up" by the progressive sector. If it is not, the loss has to be made up by imports.[14] Column 5 in the table illustrates this with imports of barley. With respect to sign change, both labor and nonagricultural inputs are handled identically to the agricultural outputs. The nonagricultural inputs[15] are calculated by use of the 1963 national input-output table for the United States.[16] However, only farm type, not economic class can be distinguished.

"Foreign exchange" coefficients (on "capital" and "current" account), depreciation coefficients, and animal "stock" coefficients are also estimated using the above-mentioned sources, plus other sources for the capital and depreciation estimates.[17]

Farm products can be used by other farmers. Column 7 in the table illustrates the transfer of barley grain produced on one farm to be used as feed grain. This can be used as hog feed (column 4) on another farm. Such feed grains include wheat, oats, and rye as well as barley. Activities such as shown in column 7 aggregate the individual grains into common-unit feed grain commodities which can be fed to farm animals, including hogs. A disaggregated agricultural commodity such as barley can be exported for use outside the multicounty region by activating column 6.

Industries in the manufacturing sector—a major user of farm products—are aggregates defined by national input-output definitions. The manufacturing sector uses barley as an input in an aggregate called grains and seeds.[18] Column 9 of the table allows for imports of the aggregate grains and seeds as an alternative to local production.[19]

Column 10 illustrates one manufacturing use of grains and seeds: production of prepared animal feeds. Columns 11 and 12 provide for imports and exports of the manufactured product. Prepared animal feeds can also become available for use by activating the regressive sector, column 1. This means that feeds formerly used by that sector are released for other uses. The feed grain commodity is similarly made available. Prepared animal feed, one of the constituents of hog feed via the conversion in column 4, is made available for use by the poultry and general farms in columns 2 and 3.

Agricultural Sector—Specific Results

Of the 12 possible types of farms considered, only poultry, class II, and general, class III, tend to be consistently selected at sizable levels by the optimal solution for most types of objective functions.[20] The first result (poultry) is "supportive" of the model's accuracy, in that poultry is, in fact, the leading agricultural activity of the BMW Region.

For land use, only cropland is used fully, while significant surpluses remain in the three pasture categories, and in the total farmland category.[21] These results are, of course, due partially to the intrinsic rigidities of activities in a linear programing format. But they are not inconsistent with the observation that pastureland is not used to capacity in the Ozarks. If transformation vectors between land categories were added to the model, some of this rigidity could be removed. Still, these results do show that cropland is preferred to pasture in the progressive agricultural sector compared with the regressive agricultural sector. This makes sense in that, generally, crops generate more net income per acre than pastureland. Thus, it is efficient to shift from regressive to progressive agriculture, even though significant surpluses of formerly used land are created.

Conclusion

To obtain useful agricultural production function data for a linear programming economic development model, we need not be tied to primary sources. A nationwide set of area-specific data is available in a widely known secondary source. This was available at the multicounty level in 1969 and earlier censuses, but currently is available only at the State level. Use of such data becomes

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[13] The RDAAP Model is an incremental and terminal year model, in which only *increases* from the base year to the target year are considered, over the planning span (10 years).

[14] These are not necessarily "true" imports. In a sense, they are an "accounting device" showing the cost to the region of such a transformation, for the particular row alone, in terms of "foreign exchange" cost (purchases from outside the BMW Region).

[15] Aggregated agricultural inputs also are included here. To avoid double-counting these inputs with those required by the animal feed unit vectors (7 feeding activities), the "overlap" is deducted from these aggregated agricultural input coefficients.

[16] Office of Business Economics, U.S. Department of Commerce, "Input-Output Structure of the U.S. Economy: 1963," *Supplement to the Survey of Current Business*, 1969 (the 478 level on computer tape).

[17] Description of this capacity methodology as well as the labor requirements procedure is given in *Generalized Model for Rural Development Planning* by Robert G. Spiegelman and Edward W. Lungren, Stanford Res. Inst., Prog. Rpt. III, USDA Contract No. 12-17-091-1-398, Menlo Park, Calif., Feb. 1969.

[18] Only the "aggregated" agricultural commodities can be used by the "manufacturing" vectors (which include such industries as meat and poultry processing) in the RDAAP Model.

[19] A "marketing" surcharge is added to the import price for the disaggregated agricultural commodities to eliminate the possibility of "cycling" with the export vectors. This surcharge also insures that aggregated, rather than disaggregated commodities will be imported for "real" uses (uses other than for the previously mentioned "accounting function").

[20] The model has been run for many different types of objectives, such as maximization of "balance of trade" surplus, "balance of payments" surplus, gross regional product, value added, local wages, local employment, total private profits and industry rate of return index.

[21] These results virtually are invariant among different objective functions, and the surpluses vary from 1/3 to 2/3 of the formerly used pastureland.

possible if the researcher modifies his usual concept of the farming sector into farm types (and economic classes), rather than using the usual concept of individual commodities. This innovative agricultural production "core" can be augmented with appropriate transfer activities to create a complete agricultural sector for an economic development model.

This procedure can perhaps be used to create any such vectors or activities for an input-output or linear programming model with joint outputs. For example, one can obtain (by special request) from the U.S. Census of Manufactures a listing by 4-digit SIC category of not only the "major" SIC category output, but also of several "minor" SIC category outputs, leading to, of course, a joint output manufacturing vector. Thus, the researcher can use inexpensive secondary data sources as an alternative to expensive primary surveys to obtain production function information.

In Earlier Issues

Is the concept of *allocative* efficiency the most appropriate one when the purpose is to compare the efficiency of agriculture with that of other sectors of the economy? When inefficiency in agriculture is described in terms of too much labor and too little capital, does this not mean, by definition, that other sectors of the economy are inefficient because of too little labor and too much capital?

Donald C. Horton
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LICENSING OF VETERINARIANS AND THE INCIDENCE OF REPORTED ANIMAL DISEASES

*By Sidney L. Carroll and Robert J. Gaston**

The Role of Veterinarians

Veterinarians, primarily, stand between the health of the human population and more than one hundred animal diseases that may affect people (such as rabies, brucellosis, tuberculosis, and psittacosis).[1] Their effectiveness in preventing and reporting the spread of these diseases has several determinants. In this note we pay particular attention to how differential licensing and schooling of veterinarians across States have affected the reported cases of animal rabies and brucellosis. It is claimed that "veterinarians, both private practitioners and regulatory officials, have played a major role in controlling rabies and bringing about a continuing decline in the number of *cases reported* (authors' emphasis) each year ... [Nevertheless] rabies remains a potential health threat that requires constant vigilance and control by veterinarians ... "[2]

While there seems to be little question regarding the instrumental role of veterinarians in the control of rabies, we know of little or no attempt to systematically analyze the trade off between presumably higher quality but fewer practitioners and the incidence of animal rabies reports in the United States. We undertake such an attempt here; moreover, we reinforce our analysis for rabies with one for animal brucellosis.

The State, in the name of protecting the "public interest", has imposed an impressive array of requirements that veterinarians must satisfy before they can be licensed. Such requirements vary by State but rather generally include such things as: gaining entry into and graduating from an "approved" school of veterinary medicine; passing competitive written, oral (sometimes, these involve actual casework) State board examinations; being a U.S. citizen; having prior residency in the State; being sponsored by existing practitioners; and others.

The Model and its Results

Using a recursive system of two equations, we first estimate the number of licensed veterinarians per household (density of veterinarians) as a function of licensing restrictiveness factors and some general control variables. Next, we relate that "density" number to the number of reported cases of rabies in dogs and cats by State.

Rabies Analysis

Cross-section data for States were available for 1970 and 1974. As the equations in table 1 show, density of veterinarians is clearly and significantly related in a positive manner to the density of farm animals (domestic farm animals in thousands per household) and the number of graduates of in-State schools of veterinary medicine. The occupational licensing requirement explicitly entered into table 1 is that of citizenship. If a State requires U.S. citizenship of a license applicant, this is given a value of 1 and, if not, a value of 0 is assigned to the State. Requiring citizenship prior to practice is considered more restrictive than not doing so.[3]

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[1] U.S. Department of Health, Education and Welfare, Public Health Service. *Health Resources Statistics*, 1972-73, Washington, D.C., p. 319. Center for Disease Control. *Zoonoses*, Atlanta, Ga., various years.

[2] Pamphlet, American Veterinary Medical Association. "Today's Veterinarian", Chicago, 1973, pp. 14-15.

[3] Of 49 States where data were available for 1970, 35 required U.S. citizenship prior to licensing. Results for a wide variety of other licensing

Table 1—Three-state-least squares estimates, recursive equation system, data pooled, 1970, 1974[1]

Density	Intercept	Time	Density of veterinarians	Farm animal density	School index	Citizenship
Veterinarians	0.3570581*** (0.025631) t=13.9310	0.0286627*** (0.024305) t=1.17929		0.026795*** (0.00164) t=16.3208	0.8030479*** (0.229061) t=3.50583	–0.0566023** (0.0266646) t -2.1228
Rabies reports	-0.0083340 (0.004230) t–1.96910	0.0012848 (0.002959) t=0.43416	0.0308268*** (0.00735) t=4.19407			

Time: 1974 = 1; 1970 = 0.
Number of observations = 98.
*Significant at 10% level, 2-tail t-test.
**Significant at 5% level, 2-tail t-test.
***Significant at 1% level, 2-tail t-test.
[1] Reported rabies cases in domestic animals is dependent variable; citizenship requirement is licensure variable.
Note: Source data available from authors on request.

Table 2—Three-stage-least squares estimates, recursive equation system, data pooled, 1970, 1974[1]

Density	Intercept	Time	Density of veterinarians	Farm animal density	School index	Citizenship
Veterinarians	= 0.33293545*** (0.02590346) t=12.85294	0.02821018 (0.02430521) t=1.16066		0.02622825*** (0.00164414) t=15.95254	0.89240918*** (0.23547287) t=3.80440	-0.02180551 (0.02733826) t=-0.79762
Brucellosis reports	= -0.40318324 (1.56355600) t=-0.25786	1.29405158 (1.09368802) t=1.18320	5.19092362* (2.71652585) t=1.91087			

*Significant at the 10% level, 2-tailed t-test.
**Significant at the 5% level, 2-tailed t-test.
***Significant at the 1% level, 2-tailed t-test.
Number of observations = 98.
Note: Source data available from authors on request.
[1] Brucellosis in animals is dependent variable; citizenship requirement is licensure variable.

The negative sign on the coefficient "citizenship" is consistent with its use as a restrictive device via its association with reduced density of practitioners. Further, the statistical significance of the coefficient lends some empirical support that such requirements function as barriers to entry into the field of veterinary medicine.

Particularly striking in table 1 is the importance and positive effect of the presence of an in-State school of veterinary medicine on the density of practitioners in that State. This strong relationship, found in every statistical sample tested, highlights the importance to a State of having its own system of veterinary medical education. It also suggests that the school entry requirement is a significant licensing barrier and that the functioning of license reciprocity among States does not fully compensate for lack of an in-State school of veterinary medicine.

It is abundantly clear in table 1 that, as the density of veterinarians in a State increases, so does the number of *reported* cases of rabies. This relationship is significant at even the most stringent level of statistical testing. More veterinarians equals more reported rabies, when other influences are held constant. This relationship obviously does not suggest in any way that veterinarians cause rabies; rather that more existing rabies cases are detected and reported the more veterinarians there are practicing.[4] One possible implication is

requirements showed basically the same result as that with this measure, but they are omitted for brevity. Further, the statistical results were "strongest" with this measure of restriction.

[4] The number of reported cases of rabies also depends somewhat on State laboratory budget and testing policies which vary from State to State and over time. These policies dictate under which circumstances animals will be tested and, of course, alter the discovered (*reported*) number of rabies cases. Further testing with 3-year averages of reported cases of animal rabies to reduce the influence of transient changes in public laboratory examination policies revealed no changes in any coefficient sign or significance level.

that in those States most restrictive in the licensing of veterinarians (most demanding of high quality or stringent with educational funds), there may be systematic under-discovering of existing cases of rabies, and an increase in the risk of exposure to other animals and, ultimately, to people.[5]

Animal Brucellosis Analysis

The equation system and variables used in table 1 were tested to examine the incidence of brucellosis in animals (table 2). The most striking finding from a comparison of the rabies and brucellosis analyses is that, with minor exceptions, the results for brucellosis almost exactly mirror those obtained for rabies. Namely, as the density of veterinarians increases, so do the reported cases (per household) of brucellosis in animals. The citizenship variable retains the expected sign but shows little statistical significance.

Testing of additional licensing requirement variables (such as practical examination reciprocity and written examination pass/fail rates) revealed the same positive and significant relation between density of veterinarians and density of reported cases of animal brucellosis. However, the results were sometimes positive and sometimes negative, but not statistically significant, in the relationship between various explicit licensing requirements tested and the associated density of veterinarians. The veterinary school influence was always highly significant in any model tested.

Conclusion

We can tentatively report that, the more strict the barriers in a State to obtaining a veterinary license, the fewer the practitioners in the State. As a result, some cases of rabies and brucellosis are not being discovered. Thus, the risk of infection increases, for healthy domestic animals and, ultimately, for people.

[5] Alternative explanations are not excluded, such as "higher quality" vets reducing the number of *actual* cases and hence, the reported number. However, we have no knowledge of the effect of fewer veterinarians on the number of actual cases of animal rabies.

ESTIMATING THE NUMBER OF HIRED FARMWORKERS COVERED BY SOCIAL SECURITY

*By Bertram M. Kestenbaum**

The number of farmworkers in a given year covered by social security differs from the number of employer-employee reports because one worker may have several employers. For a significant number of reports the employee's identity cannot be determined, and it becomes necessary to estimate what number should be added to the count of identified workers to arrive at a total. In this note, I present a solution, an innovative application and extension of methodology developed originally to treat the problem of multiple listings in a sampling frame.

Hired farmwork has been covered under the Social Security Administration's (SSA) old age, survivors, disability, and health insurance program since 1951. Each farm operator is required to report at the year's end the name, social security number (SSN), and cash wages of any employee who either earned at least $150 or was paid on a time basis (hourly, weekly, and so on) for 20 or more days of work during the year. The size of the hired farm workforce covered by social security can be used to assess program coverage and describe trends in noncasual farm employment.

Although many of these workers are employed by two or more farm operators during the year, the number covered by social security in a given year could be determined, in theory, simply by counting the number of different SSN's appearing on farm employer reports. Actually, because SSA's statistical data base consists of a 1-percent sample of social security numbers (described elsewhere[1]), one would count the number of different SSN's in the 1-percent sample that appear on farm employer reports, then multiply by 100.

However, the name/SSN identification on reports of farm employment is sometimes incomplete or incorrect. Perhaps the worker couldn't produce an SSN; or perhaps the employer misplaced the information and was unable to contact the former employee. To illustrate: for 1974 there were 3,042,000 farm employment reports; only 25,919 of the 30,420 reports expected in the 1-percent sample had acceptable name/SSN identification.

The properly identified 25,919 reports yielded 19,874 different SSN's. I denote these two quantities by "y" and "x", respectively. "Y" and "X," respectively, stand for the numbers of reports (30,420) and unique SSN's expected in the 1-percent sample if all reports had acceptable identification. The objective is to determine the value of X.

A first approximation is obtained by solving the equation:

$$X = \frac{x}{y} \cdot Y = \frac{19{,}874}{25{,}919} \cdot 30{,}420$$

from which X = 23,325 for 1974. This procedure would be satisfactory if every farmworker were correctly identified either by all his employers or by none. But, because it is possible that a farmworker will be properly reported by some employers and not by others, the procedure yields an overestimate: that is, the extent of duplication in a list is understated by a partial examination of the list.

To solve the "unduplication" problem, I expand upon methodology originally developed by Leslie Kish for calculating probabilities of element selection from a sampling frame with replicate listings.[2] It consists of applying a binomial model with

*The author is a mathematical statistician with the Social Security Administration. He is indebted to Miles Davis for his help.

[1] Social Security Administration, Office of Research and Statistics. *Earnings Distributions in the United States, 1969.* Washington, D.C., 1975, pp. 316-318. See also Mandel, B. T. "Sampling the Federal Old-Age and Survivors Insurance Records. *Journal of the American Statistical Association,* vol. 48, no. 263, September 1953, pp. 462-475.

[2] Leslie Kish. *Survey Sampling.* New York, 1965, pp. 392-393. Also, see estimating techniques used in the 1969 Census of Agriculture as described by Gurney and Gonzalez in "Estimates for Samples from Frames Where Some Units Have Multiple Listings." *1972 American Statistical Association Proceedings, Social Statistics Section.* 1973, pp. 283-288.

parameter "p"—the probability of proper identification—constant from trial to trial (report to report).

For a worker with "i" employers, according to our model the probability that exactly "j" (j=1,2,...,i) of his employments are correctly identified is given by:

$$p_{ji} = \binom{i}{j}\binom{Y-i}{y-j}\Big/\binom{Y}{y}$$

This expression can be approximated by the jth term in the expansion of $((1-p)+p)^i$, where $p = y/Y$; and this is the relationship used:

$$p_{ji} = \binom{i}{j}(1-p)^{i-j}p^j$$

For 1974,

$$p = \frac{25{,}919}{30{,}420} = 0.85204.$$

Next, it is necessary to know, among correctly identified farm employment reports, how many SSN's appeared on exactly one report, two reports, three reports, and so on (see table).

It is unlikely that any worker has more than, say, 14 employers. Let $C = (c_j, j=1,2,\ldots,14;\ c_{12}=c_{13}=c_{14}=0)$ be the column vector whose elements are the numbers of SSN's appearing on exactly j correct reports, and $T = (t_i,\ i=1,2,\ldots,14)$, the column vector whose elements are the numbers of SSN's which would appear on exactly i reports if all reports were properly identified. The objective is to solve for $X = \Sigma t_i$, by assuming that the values (c_j) derive from the values (t_i), according to the probabilities:

$$p_{ji} = \binom{i}{j}(1-p)^{i-j}p^j.$$

We array these probabilities in a 14 X 14 matrix, P:

	i=1	i=2	i=3	i=4	. . . .
j=1	.85204	.25214	.05596	.01104	. . . .
j=2	0	.72597	.32225	.09536	. . . .
j=3	0	0	.61855	.36609	. . . .
j=4	0	0	0	.52703	. . . .
.	.	.	.	.	. . . .
.	.	.	.	.	. . . .
.	.	.	.	.	. . . .
.	.	.	.	.	. . . .

P is an upper triangular matrix whose elements along the main diagonal, p^i, are all nonzero. Therefore, its inverse, P^{-1}, must exist, and we may solve the matrix equation PT = C for $T = P^{-1}C$.

The result is a total of 22,629 farmworkers in the 1-percent sample in 1974. The number of workers added, $X-x$, is 2.755, substantially less than the workers added (23,325–19,874=3,451) according to the first approximation.

This method, a general one, can be applied in other subject areas when it is necessary to estimate the duplication in some file after most of the duplication has been determined by random observation.

Hired farmworkers and total correct reports for workers with exactly j correct reports, 1974

Number (j) of correct reports per worker	Number of workers with exactly j correct reports	All correct reports
1	16,254	16,254
2	2,351	4,702
3	694	2,082
4	284	1,136
5	135	675
6	75	450
7	48	336
8	18	144
9	12	108
10	1	10
11	2	22
Total	19,874	25,919

Source: Social Security Administration's 1% statistical sample.

RESEARCH, EXTENSION, AND TEACHING UNDER TITLE XIV

*By James Nielson**

"Title XIV is the most comprehensive and important legislation in the area of agricultural research and extension ever undertaken by the Congress." Thus spoke Congressman Tom Foley when he presented the conference report on what was later called the "Food and Agriculture Act of 1977." Title XIV is called the "National Agricultural Research, Extension, and Teaching Policy Act of 1977." This act indicates priorities for programs, and specific organizational structures and procedures for carrying out the programs.

The legislation names USDA as the lead agency for food and agricultural sciences in research, extension, and teaching. It carves out for the Department and cooperating universities a dominant piece of the action in all areas of agriculture, forestry, aquaculture, home economics, human nutrition, family life, and rural and community development. There is to be increased cooperation, coordination, and planning in the food and agricultural sciences among Federal departments and agencies, the States, colleges, universities, private research and extension organizations, agricultural libraries and user groups. The Congress—in Subtitle B—established a committee, a council, and two boards to accomplish these activities.

The committee, to be called the Subcommittee on Food and Renewable Resources, will be under the Federal Coordinating Council on Science, Engineering, and Technology. It will review Federal research and development programs relevant to domestic and world food and fiber production and distribution, and will promote planning and coordination within the Federal Government.

The council, to be named the Joint Council on Food and Agricultural Sciences, will assist the Department in carrying out its research, extension, and teaching responsibilities through coordination of regional

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and national planning. The Council will develop recommendations and reports describing current and long-range needs, priorities, and goals.

One of the two boards is to be called the National Agricultural Research and Extension Users Advisory Board. It will contain persons representing producers, consumers, farm suppliers, processors, marketing interests, environmentalists, rural development, human nutrition, animal health, transportation, labor, and private international development activities. The responsibilities are to review, assess, and provide recommendations on national policies, priorities, strategies, and programs of research and extension for both the short and long term.

The second board is to be called the Animal Health Science Research Advisory Board. Its duties are to make recommendations on the animal disease provisions of the legislation and on priorities for animal disease research programs.

There are 11 subtitles under Title XIV. Subtitle A emphasizes that research, extension, and teaching are distinct missions of the Department. Food and agricultural sciences are defined to include economic considerations of all aspects of agriculture and forestry, including, among other areas, aquaculture, human nutrition, family life, and rural and community development.

As mentioned, Subtitle B sets up the committee, council, and boards. Their primary purpose is to foster coordination of the research, extension, and teaching activities of the Federal Government, the States, colleges and universities, and other public and private institutions and persons involved in the food and agricultural sciences. I think this multidisciplinary and multi-institutional effort is a major issue for agricultural economists. ESCS has not been highly supportive of regional research but has participated actively and effectively in the regional and national planning effort. It is important that we have appropriate mechanisms and enthusiastic support for multidisciplinary, multi-State, multiagency projects, some of which need large blocks of resources to succeed.

Subtitle C strengthens the USDA competitive grants and fellowships program by broadening Department authority to extend grants and awards for research that furthers USDA programs. Agricultural economists are eligible to compete for the mission-oriented basic research grants in human nutrition being offered in FY 1978.

Two annual National Agricultural Research Awards are set up by Subtitle C. One will be given to an outstanding senior scientist. The other will go to a research scientist in early career development or to a graduate student. The awards will be in the form of research grants up to $50,000 annually for a period of 3 years.

Subtitle C also contains a provision for grants for research on alcohol and industrial hydrocarbons and for pilot projects on their production and marketing. Agricultural economists will be called upon to assist in assessing the economic feasibility of such research.

Subtitle D makes food and human nutrition research and extension programs a major thrust for the Department. Research is encouraged on nutritive requirements and their relation to health, and on the nutritional impacts of USDA's food programs. Studies are encouraged of the impacts of food preferences and habits on nutrition and of practices related to production, handling, and processing.

Subtitle E promotes research, teaching, and extension related to improved health of domestic and wild animals. Both regional and national problems are to be considered.

Subtitle F contains authorization for small farms research and extension. It amends the Rural Development Act of 1972 to provide for improved programs on production, management, and finance. A small farmer means any farmer with gross sales from farming of $20,000 or less per year.

Subtitle G provides continuous funding to 1890 institutions and Tuskegee Institute for research and extension while Subtitle H provides for competitive grants in solar energy research.

Subtitle I calls for expansion of USDA's role in international research and extension with developed and developing countries, in coordination with other Federal agencies. It authorizes stationing of U.S. scientists in national and international institutions of other countries, assistance to U.S. colleges and universities in strengthening their capabilities in development activities overseas, and assistance in career development of scientists who specialize in international programs.

Subtitle J requests special studies and reports that will involve both Federal and State personnel. The studies are to be on the cooperative extension service, weather and water allocation, organic farming, research facilities, human nutrition research centers, a nutritional status monitoring system, and a plan for implementing a national food and human nutrition research and extension program.

Subtitle K authorizes appropriations for existing and certain new agricultural research programs.

The charge from the Congress to all of us is to increase cooperation and coordination in research, extension, and teaching. In carrying out this cooperation and coordination, the Congress also made it clear that the traditional land-grant USDA system, effective as it is, must be broadened to include other research and educational institutions and organizations. This broadening of participation is to include the private sector to the extent possible.

We have two major challenges before us in regard to coordination and planning. One is to improve the existing system; the other is to work more closely with others and bring them into the partnership.

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